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# **SUGARBEET RESEARCH**

**1971 REPORT**

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SUGARBEET INVESTIGATIONS

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PLANT SCIENCE RESEARCH DIVISION

AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

A Report to and for  
the Sole Use of Cooperators

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## F O R E W O R D

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Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture or the Beet Sugar Development Foundation.



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ABSTRACTS OF PAPERS APPROVED FOR PUBLICATION IN 1971

COE, GERALD E. and GEORGE J. HOGABOAM. Registration of US H20 sugarbeet. Crop Sci. 11: 942. 1971.

A description of the parentage and varietal characteristics of US H20.

COE, GERALD E. and GEORGE J. HOGABOAM. Registration of sugarbeet parental line SP 6322-0. Crop Sci. 11: 947. 1971.

A description of the origin and characteristics of the pollinator line SP 6322-0.

CRESSMAN, R. M. The use of Ba(OH)<sub>2</sub> in methanol for demonstration of the distribution of sucrose in sugarbeet roots. Stain Technol. (In press).

Sucrose in the tissues of the sugarbeet (Beta vulgaris L.) can be shown as follows. Fresh or stored roots are cut into pieces having a block face of about 1 x 2 cm, and sections of about 150  $\mu$  thickness prepared from these. The sections are rinsed 15-30 sec in iced distilled water, placed in Ba(OH)<sub>2</sub>-saturated methanol for 3 min and then rinsed twice in methanol for 1 and 5 min respectively. They are then transferred to ethanol through a graded series consisting of 80, 60, 40, and 20% methanol in ethanol, 5 min in each, evacuation as necessary to remove bubbles. Temporary mounting is in ethanol and examination made by incident light or darkfield illumination. Gradual replacement of ethanol with xylene permits mounting in a resinous medium. An opaque granular precipitate of barium saccharate shows the location of the sucrose within the cells.

CRESSMAN, R. M. Studies on the permeability of sugarbeet tissue to stored sugar. J. Am. Soc. Sugar Beet Technol. (In press).

Diffusion of sugar from excised tissue of sugarbeet root (Beta vulgaris L.) was studied as a function of salt concentration from  $10^{-5}$  to 1.0 M, of pH from 4.5 to 9.0, and of temperatures from 24-65 C. Rates of diffusion varied considerably among beets and methods of selecting samples for minimum variation among treatments are given. Rates of diffusion of sugar from washed tissue were inversely related to salt concentration up to about 0.2 M and were minimal at a pH of about 6.5. Rate of diffusion increased with increasing temperature until extraction was complete. The rates were progressively lower with higher salt concentrations until thermal damage to the cells occurred. Sugar loss from intact cells could be separated into a stage attributable to loss from the apparent free space and a stage attributable to diffusion through the protoplasmic

membrane. Sugar in the apparent free space constituted 13-18% of the total sugar in the tissue. The significance of permeability for studies on sugar accumulation and the storage of beets is mentioned.

DONEY, D. L., J. C. THEURER, and R. E. WYSE. Mitochondrial complementation in sugarbeet. Crop Sci. (In press).

Tightly coupled mitochondria were isolated from roots of 10-week old sugarbeet (*Beta vulgaris* L.) inbreds and hybrids as well as inbreds in the bolting stage of growth. Mitochondrial oxidation and phosphorylation (ADP:O and R:C ratios) using alpha keto glutamate as substrate were measured for each inbred, 1:1 mixtures of the inbreds, and for the hybrids. 1:1 mixtures of inbreds had ADP:O and R:C ratios larger than either inbred parent for combinations that exhibit heterosis for root yield (complementation), and ADP:O and R:C ratios between the two inbred parents for combinations that do not show heterosis. Heterotic hybrids had ADP:O and R:C ratios slightly larger than the 1:1 mixtures.

DUFFUS, JAMES E. Role of weeds in the incidence of virus diseases. Ann. Rev. Phytopathology 9: 319-340. 1971.

From the standpoint of control of virus diseases, there is perhaps no phase of virology more important than epidemiology. The role of weeds in the occurrence and spread of plant virus diseases is an integral part of the ecological aspect of virus transmission. The epidemiology of a virus disease in a given area may be a highly complex phenomenon involving a number of wild hosts, commercial crops, and different insects. The key in many plant-virus interrelationships is the role of weeds. The role of weeds in the incidence of virus diseases is discussed in relation to vector reservoirs, virus reservoirs, virus and vector reservoirs, host plant succession, viruses as pathogens of wild plants, influence on virus severity, dissemination of viruses, origin of viruses, weed control and virus incidence, and as sources of resistance. Although wild plants may have played a role in the origin of virus diseases of crop plants, and serve as significant factors in their perpetuation--through modern weed control procedures and their utilization as breeding material--they may ultimately serve in the control of these destructive diseases.

DUFFUS, JAMES E. Beet western yellows virus. Commonwealth Micological Instit., Assoc. Appl. Biologists. Descriptions of Plant Viruses. No. 89, June 1972 (In press).

A description of beet western yellows virus including information on geographical distribution; diseases caused; host range and effects on plants, modes of transmission; purification; serology; properties, composition and structure of particles; distinguishing features; and naming.

DUFFUS, JAMES E. Beet yellow stunt, a potentially destructive virus disease of sugarbeet and lettuce. Phytopathology 62: 161-165. 1972.

Beet yellow stunt, a potentially destructive yellows-type virus disease of sugarbeet and lettuce is recognized as being distinct from other yellowing diseases affecting these crops. Sowthistle is the principal reservoir host of the virus, and of the most efficient vector, Nasonovia lactucae. The disease is widespread and abundant on this host in California throughout the year. Spread in susceptible crops tends to be marginal, i.e., the disease incidence is high in rows adjacent to areas where sowthistle is prevalent but becomes progressively less with increased distance from the virus source. Host range of the virus seems limited, but it can induce serious damage to infected sugarbeet and lettuce. The virus has not been transmitted mechanically or by seed, but is transmitted in a semipersistent manner by N. lactucae, Myzus persicae, and Macrosiphum euphorbiae.

ESAU, KATHERINE and LYNN L. HOEFERT. Ultrastructure of sugarbeet leaves infected with beet western yellows virus. J. Ultrastructure Res. (In press).

An electron microscope study of sugarbeet (Beta vulgaris L.) leaves infected with beet western yellows virus (BWYV) revealed isometric particles, 24-30 nm in diameter, in phloem and mesophyll cells. Compared to ribosomes, the particles were slightly larger, more deeply stained, and sharper in outline. Many particles showed an electron lucent center. The particles are assumed to be the virus. A comparison of leaves of different ages from the same systemically infected plant suggested the following sequence in the spread of the virus. In a given leaf, the particles appear initially in mature sieve elements, then move to adjacent companion and parenchyma cells. From these cells, the virus spreads to phloem and mesophyll cells not in contact with the sieve tubes. The presence of virus particles in plasmodesmata between sieve elements and adjacent nucleate cells, as well as between contiguous parenchyma cells, indicates that complete particles are transported from cell to cell through plasmodesmata. Within the sieve tube, the particles traverse the sieve plates, for they frequently occur in sieve plate pores jointly with the P-protein. In the lumen of the sieve element, the particles occur close to the cell wall, sometimes in association with endoplasmic reticulum. In parenchyma cells (including companion cells), particles are most conspicuous and most numerous in the nuclei. Their close association with the nucleolus suggests that the latter may be involved in viral multiplication. In older infected leaves, particles within the nuclei form crystalline arrays. Within the cytoplasm, particles are commonly located close to the wall and may be aligned along the microtubules.

ESAU, KATHERINE and LYNN L. HOEFERT. Development of infection with beet western yellows virus in the sugarbeet. Virology (In press).

Electron microscopy of successively older leaves of sugarbeet (Beta vulgaris L.) infected with beet western yellows virus (BWYV) revealed the steps in the infection of leaf tissues by the virus and gave some insight into the events leading to viral multiplication in host cells. The sequence of the infection is interpreted as follows. Virus particles enter mature sieve elements before external symptoms develop in the leaf. Particles then appear in parenchyma cells next to plasmodesmata connecting the parenchyma cells with infected sieve elements. The invasion of parenchyma cells by the virus is accompanied by development of vesicles containing networks similar to those usually interpreted as nucleic acids. The vesicles are enclosed in endoplasmic reticulum (ER) cisternae, singly or in groups. Some of the vesicle-containing ER fuses with the nuclear envelope so that the vesicles become located in the perinuclear space. After the vesicles and the nuclear envelope become associated, virus particles appear in the nucleus, first next to the nucleolus. As the amount of virus increases, particles are scattered throughout the nucleus. Virus particles also increase in number in the cytoplasm, presumably by being released from the nucleus. Eventually, the virus-induced vesicles cease to be seen in association with the nucleus. Those remaining in the cytoplasm degenerate. The infected cells also degenerate. Virus multiplication first occurs in cells next to infected sieve elements. Later, cells farther away from the sieve elements also become infected.

HECKER, R. J. and J. O. GASKILL. Registration of FC 701 and FC 702 sugarbeet germplasm. (Approved by PSR Div. for publication in Crop Science).

The sugarbeet lines FC 701 and FC 702, having resistance to Rhizoctonia root and crown rot, were developed by the Plant Science Research Division, and officially released. Both FC 701 and FC 702 are the product of four cycles of selection for resistance to Rhizoctonia solani Kuehn., and were selected from open-pollinated commercial type varieties. FC 701 and FC 702 are the first sugarbeet lines with substantial Rhizoctonia resistance. They may be useful as pollinators in hybrid variety production or as a source of resistant germplasm.

HECKER, R. J. and G. A. SMITH. Ineffectiveness of low temperature alone for floral induction of sugarbeet seed. J. Am. Soc. Sugar Beet Technol. (Submitted for publication).

In an attempt to reduce the labor and facilities necessary for photothermal induction, and to shorten the life cycle of sugarbeet (Beta vulgaris L.), seed was treated as though for germination, except it was held in darkness at 5 C for up to 90 days. After this vernalization the seed was planted into soil, and kept at 22 C under continuous light (daylight and incandescent light). Only one out of six varieties showed

significant bolting (seed stalk growth). This variety was the only one which germinated and produced radicles during vernalization. Low temperature by itself apparently is not sufficient to induce floral growth. It appears that some growth during vernalization is necessary, followed by relatively cool temperature and long photoperiod.

HOEFERT, LYNN L. Ultrastructure of tapetal cell ontogeny in Beta. Protoplasma 73: 397-406. 1971.

Tapetal cell development and degeneration in anthers of Beta vulgaris L. were studied with the electron microscope. Tapetal cells become differentiated from sporogenous cells early in anther ontogeny. The tapetal nuclei divide mitotically; binucleate tapetal cells contain relatively little endoplasmic reticulum and otherwise resemble meristematic cells of higher plants. There follows an increase in endoplasmic reticulum and by the time the sporogenous tissue has entered meiotic prophase, the tapetal cells have differentiated the usual characteristics of secretory cells. Degenerative changes begin to appear in tapetal cells after meiosis of the sporogenous tissue. Such changes include loss of inner tangential and anticlinal walls, degeneration of tapetal nuclear envelopes, disruption of the plasmalemma, and changes in the cytoplasmic organelles. Coated tubules are associated with tapetal nucleoli during degenerative stages and the tubules persist after tapetal nuclei have degenerated. Tapetal cell cytoplasm disappears completely by the stage of microspore mitosis.

MAAG, G. W. and R. J. HECKER. Recovery of mercury in solution. J. Environ. Quality (In press).

Mercury in the metallic or ionic form is a poisonous pollutant when added to the sewage system. Analytical laboratories frequently use solutions which contain mercury salts and proper disposal of the waste solution is a problem. A recovery method is described in which aluminum releases its higher energy valence electrons to the mercury ions in solution producing aluminum ions and metallic mercury. The metallic mercury is recovered and the waste solution containing the aluminum ions can be poured down the drain.

MAAG, G. W., R. J. HECKER, and P. A. WHITAKER. Techniques for leaf sampling and automated analysis of sugarbeet leaf amino acids. J. Am. Soc. Sugar Beet Technol. (In press).

Techniques for leaf sampling, sample preparation and automated analysis for sugarbeet leaf amino acids are described. Twenty-one free amino acids and two amides were quantitatively determined and several other amino acids identified in three transverse sections of medium aged leaves and in the mid-transverse section of three different aged leaves. Ten percent sulfosalicylic acid solution was used for sample deproteinization and grinding medium. Hydrazine sulfate, the reducing agent used with ninhydrin, eliminated most color factor problems in the automated amino acid analysis.

McFARLANE, J. S. and I. O. SKOYEN. Registration of US H9A and US H9B sugarbeet. Crop Sci. 11: 942. 1971.

A description of the parentage and varietal characteristics of US H9A and US H9B.

McFARLANE, J. S., I. O. SKOYEN, and R. T. LEWELLEN. Registration of US H10A and US H10B sugarbeet. Crop Sci. 11:942. 1971.

A description of the parentage and varietal characteristics of US H10A and US H10B.

McFARLANE, J. S., I. O. SKOYEN, and R. T. LEWELLEN. Registration of sugarbeet parental lines. Crop Sci. 11: 946. 1971.

A description of six lines that are used as parents in US H9 and US H10 hybrid varieties.

McFARLANE, J. S., I. O. SKOYEN, and R. T. LEWELLEN. Performance of sugarbeet hybrids as diploids and triploids. Crop Sci. 12: 118-119. 1972.

The pollen parents of two diploid sugarbeet (Beta vulgaris L.) hybrid cultivars were converted from diploids to tetraploids. The root yield of triploid hybrids produced with tetraploid pollinator 663 averaged about 10% higher than the equivalent diploid hybrids, but the sucrose concentration was reduced. The performances of triploid hybrids produced with the tetraploid pollinator 413 were similar to those of equivalent diploid hybrids. Bolting was less severe in the triploid hybrids than in equivalent diploid hybrids.

McFARLANE, J. S., I. O. SKOYEN, and R. T. LEWELLEN. Performance of multigerm triploid sugarbeet hybrids when space planted. J. Am. Soc. Sugar Beet Technol. (In press).

Tests with multigerm triploid sugarbeet hybrids showed that satisfactory performance can be obtained when they are space planted followed by stand reduction with a long-handled hoe. Germination is frequently lower in triploids than in the equivalent diploids and the number of seedlings produced per seedball is also lower. When decorticated seed of multigerm triploids was space planted, the field population after stand reduction with a long-handled hoe consisted of 79% single plants and the remaining hills were primarily doubles. Losses from undersized beets at harvest were minimal. High performing triploid hybrids with good seed germination is an aim of the breeder. These results indicate the multigerm triploids could be used pending the development of satisfactory monogerm triploids.

RUPPEL, E. G. Variation among isolates of Cercospora beticola from sugarbeet. Phytopathology 62: 134-136. 1972.

Significant differences in growth were found among 14 Colorado sugarbeet isolates of Cercospora beticola on cornmeal, V-8 juice, and sugarbeet leaf extract agar (SBLEA). Cultural appearances also differed; however, with one exception, no grouping of isolates was possible based on mutual characteristics on all media. Significant differences among isolates, as measured by disease severity on sugarbeet seedlings, were obtained in only one of two pathogenicity tests. Differences in disease reaction among sugarbeet lines were highly significant, but the isolates x lines interaction was not significant in either test. Correlation studies indicated that neither growth on SBLEA nor spore length was associated with disease severity. Results demonstrated the variability among isolates of C. beticola, but resistance in sugarbeet to the fungus was effective against all the isolates from Colorado.

RUPPEL, E. G. Correlation of cultural characters and source of isolates with pathogenicity of Rhizoctonia solani from sugarbeet. Phytopathology 62: 202-205. 1972.

A crown and two foliar isolates of Rhizoctonia solani from sugarbeet exhibited significantly greater growth rate in culture than did six root isolates. Root isolates were assignable to anastomosis group 2, whereas the crown and foliar isolates were associated with group 4. In pathogenicity studies, all isolates incited significant damping-off; crown and foliar isolates caused significantly more foliar blight than did root isolates, with the crown isolate being intermediate; and root isolates caused more severe root rot than did the crown or foliar isolates. Disease reactions were significantly more severe in a susceptible cultivar (GW 674-56C) as compared with a resistant selection (FC 701/2) from GW 674-56C in damping-off and root rot tests. Root isolates x lines interactions were nonsignificant, which indicated that resistance of FC 701/2 is effective against several diverse isolates of the pathogen.

RUPPEL, E. G. Histopathology of resistant and susceptible sugarbeet roots inoculated with Rhizoctonia solani. (Submitted to Phytopathology)

Resistant and susceptible sugarbeet cultivars were penetrated by Rhizoctonia solani directly by individual hyphae or by means of infection cushions. Lesion diameter and depth were greater in susceptible roots than in resistant roots. Necroses and some tissue degeneration preceded hyphal advance in all roots. Hyphae in resistant roots usually were observed only in the periderm or secondary cortex up to 16 days after inoculation, whereas in susceptible roots the hyphae often transected several vascular rings. No phellogen or cicatrice-like cell layers were evident in resistant roots. Resistance in sugarbeet to R. solani was not found to be due to mechanical barriers to the pathogen.

RUPPEL, E. G. Negative relationship between stomatal size and density and resistance in sugarbeet to Cercospora beticola. (Submitted to *Phytopathology*)

Resistance to Cercospora beticola of sugarbeet heart leaves, as compared to susceptibility of mature leaves on the same plant, was not found to be due to size of stomatal apertures, nor to density or activity of stomata. No association was found between degree of resistance and size of apertures or stomatal density in six sugarbeet cultivars.

RUPPEL, E. G. and J. E. DUFFUS. Mechanical transmission, host range, and physical properties of the beet yellow vein virus. *Phytopathology* 61: 1418-1422. 1971.

Mechanical transmission of beet yellow vein virus (BYVV), collected from several locations in California and the Great Plains, was facilitated by addition of 0.02 M sodium sulfite to the inoculum. Spinacea oleracea served as the virus source in all studies. Of 61 species of plants, only Beta macrocarpa, B. maritima, B. vulgaris (sugarbeet), B. vulgaris var. cicla, Chenopodium capitatum, Senecio vulgaris (symptomless), and Spinacea oleracea became systemically infected with BYVV. Local lesions were formed in all Beta spp. except B. maritima, and in C. album, C. amaranthoides, C. capitatum, C. murale, C. quinoa, and C. urbicum in 6-10 days. Chenopodium quinoa was used for local lesion assays. Systemic symptoms took 12-14 days to appear in C. capitatum and spinach, whereas 25-30 days were necessary in Beta hosts.

The dilution end point of BYVV was between  $10^{-4}$  and  $10^{-5}$ , but most infectivity was lost when dilution exceeded  $10^{-2}$ . Thermal inactivation occurred between 65 and 70 C, with most infectivity lost in extracts heated over 50 C. Extracts remained infectious after being stored 48 hours at 25 C or at 3-4 C; greater infectivity occurred with extracts stored at the lower temperature. Frozen sap extracts lost infectivity within 24 hours; however, the virus remained viable in frozen tissue for 14 days.

RYSER, GEORGE K. and J. C. THEURER. Impurity index selections on individual sugarbeets. *J. Am. Soc. Sugar Beet Technol.* 16: 399-407. 1971.

The merit of utilizing an economical and easy method of individual sugarbeet selection for high and low sugar percentage and high and low impurity index was evaluated at Logan and Farmington, Utah. Recurring selections using Mendelian male sterility as a crossing tool resulted in positive selection pressure for all factors studied. Self-fertile progenies selected on an individual beet basis gave varied results, probably due to inbreeding and fixing of the genes. Progress in the direction of low quality selection was easier to accomplish than was selection toward high quality. The impurity index was an effective breeding tool for improving the beet purity of a line and still maintaining high sugar percentage.

SCHNEIDER, C. L. Steps toward control of soil-borne diseases of sugar-beet - a review. Proc. 16th Reg. Meet. Am. Soc. Sugar Beet Technol. Eastern U.S. and Eastern Canada: 20-26. 1971.

Control measures that have been developed against fungus pathogens such as Aphanomyces, Pythium, and Rhizoctonia fall into three categories: 1) the use of cultural practices that promote good crop growth; 2) the use of chemical and antibiotic agents that suppress the pathogens; and 3) the use of cultivars resistant to the pathogens. These control measures have proved to be most effective when they have complemented rather than supplemented one another.

SCHNEIDER, C. L. Pathogenicity of curly top virus isolates from Utah and Idaho on several hosts. J. Am. Soc. Sugar Beet Technol. 16: 275-278. 1971.

Three sugarbeet varieties, Turkish tobacco, tomato, Lycopersicon pimpinellifolium and Capsella bursa-pastoris were inoculated with over 30 curly top virus isolates. On the basis of the host reactions, the isolates were distributed into three to four contiguous disease severity classes. The isolates tended to occur in the same order of virulence on each of the three sugarbeet varieties. Most isolates behaved similarly to Strain 1. One behaved similarly to Strain 11. Two isolates differed from any previously reported strains in that they failed to incite symptoms on Turkish tobacco, although they were highly pathogenic on each of the other hosts.

SCHNEIDER, C. L. and H. S. POTTER. Reports of fungicide tests to control sugarbeet diseases. Fungicide and Nematicide Tests - Results of 1970 26: 102-103. 1971.

Among five seed treatments and four soil treatments, only those containing p-(Dimethyl-amino) benzenediazo sodium sulfonate provided effective protection against black root disease caused by Aphanomyces cochlioides. Each of the 15 spray treatments tested against Cercospora beticola leaf spot gave satisfactory control, with benomyl, triphenyl tin hydroxide, thiabendazole and thiophanate rated as outstanding. In tests to control Rhizoctonia crown and root rot, PCNB was the only treatment applied to the soil before planting that reduced disease damage. PCNB, benomyl and thiophanate reduced Rhizoctinia damage when sprayed into the crowns.

SCHNEIDER, C. L., H. S. POTTER, and F. B. RUSSELL. Control of Cercospora leaf spot of sugarbeet through aerial application of systemic and surface-protecting fungicides. J. Am. Soc. Sugar Beet Technol. (In press).

Aerial application of both types of fungicides reduced leaf spot under relatively severe disease exposure. There was a significant increase in root yield with four of the five treatments and an increase of net sugar with three of the treatments (thiabendazole 3 and 6 oz a.i.a., triphenyl tin hydroxide 2.38 oz a.i.a.). There were no differences in percentage sucrose and in clear juice purity between any treatments and non-treated control.

SCHNEIDER, C. L., ROBERT L. SIMS, and H. S. POTTER. Tests of fungicides to control sugarbeet leaf spot disease. Fungicide-Nematicide Tests - Results of 1971. (In press).

Among 24 chemical treatments tested, benomyl (3 oz a.i.a.) and thio-phosphate (5.6 and 8.4 oz) gave most effective control, even at 21-day schedules. Addition of sticker-spreader and spreader-activator to systemic materials did not increase their efficacy.

SKOYEN, I. O. and J. S. MCFARLANE. A plot seeder for sugarbeet field experiments. J. Am. Soc. Sugar Beet Technol. 16: 422-427. 1971.

Cone feed units were attached to commercial seeders and equipped with sprocket combinations to permit the sowing of various size plots up to 86 feet long. The commercial seeder units may be readily restored to original equipment by simply exchanging parts. Seeder frame construction provided seating for attendants and permitted simple adjustment for different bed and row spacings.

The cone-feed units were adapted to low seeding rates by installing plywood rings which reduced the seed plate width from 15/16 to 5/16 inch. Adequate stands were obtained at seeding rates of 8-10 grams per 100 feet of row. The combination of narrow seed plate and low seeding rate greatly reduced hand singling requirements.

SMITH, G. A. and E. G. RUPPEL. Cercospora leaf spot as a predisposing factor in storage rot of sugarbeet roots. Phytopathology 61: 1485-1487. 1971.

In two F<sub>2</sub> populations segregating for Cercospora leaf-spot resistance, selection of sugarbeet plants for high as compared to low leaf-spot resistance resulted in a 50% reduction in storage rot of harvested roots. Also, the degree of field leaf-spot infection closely paralleled the number of harvested roots that rotted in storage.

SNYDER, F. W. Some agronomic factors affecting processing quality of sugarbeets. J. Am. Soc. Sugar Beet Technol. 16: 496-507. 1971.

More than 3,200 samples of freshly harvested sugarbeets, grown in 69 experiments in the Great Lakes region, were analyzed for percent sucrose, clarified juice purity, alpha-amino nitrogen, potassium, and sodium. A smaller number of samples were analyzed for betaine.

The environment in which the beets grew altered the clarified juice quality more than the genetic differences of varieties grown at one location. Plant spacings of 12 in. or less in the row had relatively little effect on juice quality. Altering row width had a greater effect on juice quality. One inch of row-width contributed about the same amount of total impurities as applying 5 lb of nitrogen per acre. Potassium in the clarified

juice increased nearly 2% for each additional inch of row-width. Manipulation of in-the-row spacing of plants and row-width cannot overcome the adverse effects of higher rates of applied nitrogen. Environment from location to location and year to year altered the betaine content of the juice by two-fold.

Potassium in the clarified juice did not correlate very highly with total impurities, therefore it would not be suitable as a possible index of quality. The percentage of sucrose in the beet did not correlate well with any of the major quality indices of clarified juice and the association for any particular location or experiment was unpredictable. Betaine did not correlate well with total impurities or any other chemical constituent analyzed.

SNYDER, F. W. Relation of sugarbeet germination to maturity and fruit moisture at harvest. J. Am. Soc. Sugar Beet Technol. (In press).

Sugarbeet fruits were harvested repeatedly from individual plants at 4 to 6 days intervals to relate germination performance to maturity as measured by days from first bloom, commercial maturity based on fruit color, moisture content of the fruits at harvest, and attainment of physiological maturity.

Seeds from individual plants within a cultivar differed more than the averages between cultivars. Seeds were physiologically mature from 26 days before to 10 days after commercial maturity and when fruit-moisture contents ranged from 76 to 29% wet basis. The interval from first bloom to physiological maturity of the seeds among plants ranged from 35 to 70 days and averaged 53. Fruit color, fruit-moisture content, and interval from first bloom could not be used to predict physiological maturity precisely for any given plant.

STORER, K. R., W. R. SCHMEHL, and R. J. HECKER. Growth analysis studies of sugarbeet. Colorado State Univ. Tech. Bull. (In press).

In field experiments we studied the effects of genetic population, nitrogen fertilization, and date of planting on seasonal growth of sugarbeets. Leaf area, dry matter, and sucrose production were determined at 2-week intervals; seasonal plant growth was related to final yields. Growth rates for total dry matter, root dry matter, and sucrose were related to leaf area index (LAI) and net assimilation rate (NAR). Early planting increased early-season LAI's but had little late-season effect. Leaf area was increased by nitrogen fertilizer. Larger LAI's were negatively related to NAR, but the decreased NAR was never great enough to overcome the positive effect of increased LAI on dry matter production. With LAI held constant, 86% of the variability in NAR was accounted for by radiation; thus, dry matter growth rates were primarily determined by leaf area and light. The most efficient leaf areas were those presented earlier in the season when radiation was highest. Conditions leading to greatest dry matter production did not necessarily produce greatest root yields. Root growth rates maximized about 3 weeks after total dry matter

growth rates, indicating that top growth had priority for assimilate. Treatments which favored high root yields also increased sucrose yield; the photosynthetic potential was increased and a higher proportion of late season assimilate went into storage as sucrose. In general, leaf areas should be as large as possible early in the season and decrease with time for maximum sucrose production. LAI's greater than 5 are not likely to be beneficial on the Colorado high plains. Optimum LAI at harvest might be about 3 or less. Early planting can help achieve early season growth, within limits. Transplanting, plastic or asphalt covers, and breeding for frost tolerance may also promote early growth. Some benefit could be derived from a slow release nitrogen, however, most nitrogen would have to be depleted by harvest. Eventually it may be possible to control the plant to our advantage by means of growth regulators. However, until such advances are achieved, early planting, timely applications of nitrogen, and use of rapid emerging cold tolerant varieties are the primary means of achieving large early-season LAI's to make optimum leaf area coincide with maximum radiation.

WHITNEY, E. D. and D. L. DONEY. The effect of *Heterodera schachtii* and *Aphanomyces cochlioides* on root rot of sugarbeet. (Submitted to *Phytopathology*)

*Heterodera schachtii* and *Aphanomyces cochlioides* at high inoculum levels showed a synergistic effect in the killing of sugarbeet. A less than additive effect occurred between the two organisms as measured by yield. Positive correlations between yield and sucrose percentage and yield and nematode population were observed. Water consumption was negatively correlated with wilt. High levels of the nematode tended to predispose plants to infection by the fungus. The nematode alone killed few plants.

## SUGARBEET RESEARCH

1971 Report

### Section B

U.S. Agricultural Research Station, Salinas, California

#### Sugarbeet Investigations

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#### Cooperation:

American Crystal Sugar Company  
Holly Sugar Corporation  
Spreckels Sugar Division  
Union Sugar Division  
California Beet Growers Association

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SUMMARY OF ACCOMPLISHMENTS, 1971

YELLOWS RESISTANCE--Lines and varieties selected for yellows resistance were evaluated for performance, yellows resistance, and bolting resistance at Salinas, Brawley, and in sugar company tests. Five tests (Tests 3-7) were grown at Salinas in which various assortments of lines and hybrids were evaluated for yellows resistance using paired BYV-BWYV inoculated and noninoculated check subplots. Significant reductions for sugar and beet yield and sucrose concentration occurred for the varieties in these tests. In two of the tests (Tests 3 and 7) a significant variety x virus interaction showed that there are inherit differences between some of the lines for yellows resistance. Test 7 indicated that these differences were probably due to BYV infection. The differential effects of BWYV were not determined. Correlations between performance of the check plots and the percent reduction due to yellows infection showed that the plots with the highest percent sucrose usually had the greatest reduction in sucrose concentration, whereas plots with the highest beet yield tended to show the least reduction in beet or sugar yield. US H9 and US H10 were similar in most tests in 1971. US H10 appeared to have slightly more yellows resistance. R. T. Lewellen, I. O. Skoyen, J. S. McFarlane.

BEET MOSAIC RESISTANCE--The development of beet mosaic resistant lines equivalent to 813 (C17), Y04, Y01, etc., was continued in 1971. The resistant segregates from the B<sub>2</sub>F<sub>1</sub> crosses were again backcrossed to their respective recurrent parents. A backcross series was also initiated to obtain monogerm, type 0, curly top resistant, inbred lines. The incompletely dominant gene that conditions mosaic resistance was effective against all of the diverse isolates of beet mosaic virus tested. The infection of most other important beet viruses was not influenced by this gene. However, a possible relationship is being investigated between this gene and the symptoms produced by BYV infection. R. T. Lewellen.

NEMATODE RESISTANCE--A test was planted on land heavily infested with sugarbeet nematodes to determine the progress that had been made in selecting within B. vulgaris for nematode resistance. All selections were heavily infested and yields were low indicating severe nematode damage. Two lines selected by the Instituut voor Rationele Suikerproductie in The Netherlands for tolerance to wilting caused by nematodes produced significantly higher root yields than the nonresistant US H9 variety. They also yielded higher than selections made at Salinas and in England on the basis of relative freedom from infection (page B24). As expected, these Dutch selections showed less wilting when the test was placed under moisture stress. They were superior to US H9 and to most other selections in sucrose percentage. J. S. McFarlane and I. O. Skoyen.

US H10A AND US H10B--Commercial hybrid sugarbeet varieties developed by the U.S. Department of Agriculture are now being registered with the Crop Registration Committee, Crop Science Society of America. Recently,

additional selections were made in the pollen parent of the US H9 variety for improved sucrose concentration, virus yellows resistance, and bolting resistance. The genetic makeup of the pollen parent was altered and a new variety number was required. Seed increases utilizing this new selection as the pollen parent have been assigned the designations US H10A for the hybrid (562CMS x 569) x C17 and US H10B for the hybrid (562CMS x 546) x C17.

Variety trials conducted throughout California in 1970 and 1971 provided comparative performance information on the US H9 and US H10 hybrids:

<u>Hybrid</u>	<u>Year</u>	<u>No. tests</u>	<u>Performance in % of US H9</u>	
			<u>Gross sugar yield</u>	<u>% sucrose</u>
US H10A	1970	18	98	101
US H10B	1970	11	99	101
US H10A	1971	14	101	101
US H10B	1971	12	102	100

The US H10 hybrids tend to be a little higher in sucrose concentration than do the corresponding US H9 hybrids, but the difference between the hybrids is rarely significant. The bolting resistance of the pollen parent C17 (813) has been significantly improved over that of C13 (413), the pollen parent of US H9. Results of comparative bolting tests between US H9 and US H10 have been inconclusive. In some tests the US H10 hybrids are significantly superior, whereas in others the US H9 hybrids are superior. Additional testing is underway. J. S. McFarlane, I. O. Skoyen, R. T. Lewellen.

VULGARIS-PROCUMBENS HYBRIDS--Work is underway to develop nematode resistant lines from the B<sub>2</sub> and B<sub>3</sub> resistant trisomics and diploids. The trisomics and diploids are kept separate and allowed to interpollinate within each group. The plants obtained from these crossing blocks are then tested for resistance to nematodes. The transmission of nematode resistance from resistant trisomic and diploid plants was tested. The transmission from trisomic parents averaged 14.6 percent and from diploid parents averaged 10.3 percent. The continued selection of plants with a high frequency of transmission followed by a cytological study is necessary if lines with a high frequency of transmission is to be obtained. H. Savitsky, J. C. Read.

VULGARIS-COROLLIFLORA HYBRIDS--Curly top virus isolate 66-10 was used to inoculate 576 B<sub>4</sub> plants from curly top resistant B<sub>3</sub> hybrids. After two inoculations 24 of these plants showed no symptoms and 175 plants showed only mild symptoms. The chromosome number of plants showing no symptoms was 19 except for two with 20 chromosomes. This indicates that only one chromosome from B. corolliflora is responsible for curly top resistance. H. Savitsky, J. S. McFarlane.

VULGARIS-MACRORHIZA HYBRIDS--From crosses between tetraploid sugarbeet and diploid B. macrorhiza, 10  $F_1$  hybrids were produced. These triploid  $F_1$  hybrids were extremely vigorous and had good seed set when pollinated with sugarbeet pollen. The  $B_1$  plants were also extremely vigorous. The roots averaged 53.6 grams heavier than sugarbeet roots grown in the same test. Curly top virus isolate 66-10 was used to inoculate 127  $B_1$  plants and 85 of these showed no symptoms. Further work is being done to see if this vigor and curly top resistance can be utilized in sugarbeet breeding. H. Savitsky, J. S. McFarlane.

RELATIONSHIP OF APHID TRANSMITTED YELLOWING VIRUSES--Beet yellow stunt, a potentially destructive yellows-type virus disease of sugarbeet is recognized ■ being distinct from other yellowing diseases affecting the crop. The disease is widespread and abundant on sowthistle. Host range of the virus is limited, but it can induce serious damage to infected sugarbeet. The virus has not been transmitted mechanically or by seed, but is transmitted in a semi-persistent manner by Nasonovia lactucae, Myzus persicae and Macrosiphum euphorbiae.

Turnip yellows virus, common in Europe and capable of causing severe damage to infected plants, has many similarities to beet western yellows virus. Host range, transmission tests, density-gradient centrifugation and infectivity neutralization tests have established a close serological, and epidemiological relationship between beet western yellows virus from America and England, and turnip yellows virus from England and Germany. J. E. Duffus.

CYTOLOGICAL EFFECTS OF SUGARBEET VIRUSES--The effects of beet yellows virus on New Zealand Spinach (Tetragonia expansa L.) were studied with the electron microscope. Virus particles were found in vascular tissues and were seen in plasmodesmata between vascular cells and adjacent leaf mesophyll cells. In progressively older leaves, virus particles accumulated in cells of the phloem and often appeared to undergo structural changes that led to the conclusion that in yellow leaves, virus particles themselves degenerated. Virus particle degeneration may explain the lack of virus transmission from yellowed leaves. L. L. Hoefert.

ULTRASTRUCTURE OF TAPETAL CELL ONTOGENY IN BETA--Development of tapetal cells from early differentiation to ultimate degeneration were studied in sugarbeet anthers by electron microscopy. Normal development and degeneration were investigated as a prelude to studies of tapetal cell ontogeny in cytoplasmic male sterile lines. Preliminary work indicates that precocious tapetal cell degeneration is a key characteristic of cytoplasmic male sterility. L. L. Hoefert.

ROOT ROT STUDIES--Previous tests showed a synergistic effect between Pythium ultimum and Heterodera schachtii on damping-off of sugarbeet but an additive effect between P. aphanerodimatum and H. schachtii. Similar tests of these complexes on root-rot showed the effects to be additive.

A survey of sugarbeets grown in central and southern California in 1971 does not support the common belief that Rhizoctonia solani is the major incitant of root-rot in these areas. Of 31 fields of beets tested only 16.1% of the fields showed R. solani to be the major cause of rot, while 38.7% had at least some beets killed by the fungus. Tests of Rhizoctonia root-rot resistant selections showed that root-rot resistance does not confer resistance to crown-rot isolates of the fungus. E. D. Whitney.

EFFECT OF ROTATION, SOIL FUMIGATION, AND FERTILIZER--Study was continued in 1971 on the effects of rotation, soil fumigation, and fertilizer levels on yield and purity of two sugarbeet varieties. The second year's results of a three-year study showed no differences between first year and second year beets for gross sugar, root yield, and percent sucrose. Three-year beet plots had significantly lower gross sugar and root yields. The greatest increase in yield was with the first increment of fertilizer (87 lbs.). Fumigation increased yield more following beets than no beets and was generally equal to the first increment of fertilizer applied following beets. The highest nitrogen level (244 lbs./A) reduced percent sucrose significantly. US H9B was superior to US H7A in yield and tolerance to soil organisms, the same response as in 1970. I. O. Skoyen and E. D. Whitney.

VARIETY TRIALS, SALINAS, CALIFORNIA, 1970-71

Location: USDA Agricultural Research Station  
Soil type: Sandy loam (Chualar series).  
Previous crops: Barley, 1968; fallow, 1969; barley cover crop, 1970.  
Fertilizer used: The 1970-71 yield trial field received a ton per acre (/A) agricultural lime (85% CaCO<sub>3</sub>) broadcast with disc incorporation to about 6" depth. Tests 1 and 2 (bolting evaluation trials) planted November 18-19, 1970. Preplant: 700 lbs./A 0:10:10 broadcast and chiseled in before listing; 87 lbs./A actual N, as ammonium sulfate. Sidedressing: 96 lbs./A actual N, as ammonium sulfate, on May 10, 1971.

Tests 3 and 4 (yellows inoculated vs. noninoculated variety yield trials) planted January 28-29, 1971. Preplant: 700 lbs./A 0:10:10 broadcast and chiseled in before listing; 93 lbs./A actual N, as ammonium sulfate. Sidedressing: 96 lbs./A actual N, as ammonium sulfate, on May 10, 1971.

Tests 5, 6, and 7 (yellows resistance evaluation trials) planted May 5-7, 1971. Preplant: 570 lbs./A 15:8:4 (85 lbs. actual N), incorporated in the beds. Sidedressing: 48 lbs./A actual N, as ammonium sulfate, on August 5, 1971.

Thinning dates: Tests 1 and 2, January 26-27, 1971.  
Tests 3 and 4, March 23-29, 1971.  
Tests 5, 6, and 7, June 9, 1971.

Harvest dates: Tests 1 and 2, September 13-15, 1971.  
Test 3, September 20-22, 1971.  
Test 4, September 27-30, 1971.  
Tests 5 and 6, October 12-13, 1971.  
Test 7, October 14, 15, and 18, 1971.

Irrigation: By sprinkler system (Tests 1-4) and furrow (Tests 5-7) as required at 10-14 day intervals throughout season.

Diseases and insects: Virus yellows infection was moderate during 1971. Spray applications of Meta Systox R appeared to control the spread of yellows infection into noninoculated plots until late in the season. The various tests were sprayed twice with Meta Systox R (2 pints/A) for control of aphid and leafminer, and from one to three times with Diazinon (1½ pints/A) for control of leafminer. These applications were made between March 8 and August 15, 1971.

Experimental design: Tests 1 and 2, bolting evaluation trials of 30 entries with 5 replications, plots 53' long; and 52 entries with 4 replications, plots 32' long, in randomized block design.

Tests 3, 4, 5, 6, and 7 were randomized block design with blocks split for comparing yellows inoculated vs. noninoculated plots. Test 3 had 27 entries with 10 replications (replication grouping was 1-5 the length of the field and 6-10 repeated the length of the field), sown in single-row plots 53' long. Test 4 had 21 entries with 10 replications (replication grouping the same as for Test 3), sown in two-row plots 53' long. Tests 5 and 6 had 18 and 10 entries, respectively, with 5 replications sown in single-row plots 53' long. Test 7 had 10 entries with 12 replications sown in single-row plots 32' long.

**Sugar analysis:** Determined from two samples per plot of approximately ten roots each at the sugar analytical laboratory, United States Agricultural Research Station, Salinas, California.

**Remarks:** Reliability was good for Tests 1, 2, and 3; fair for Test 4, and poor for Test 5. Tests 6 and 7 were good in spite of late planting.

The assistance of Dr. Gary V. Richardson, Biometrical Services staff, Statistical Laboratory, Fort Collins, Colorado, and Dr. F. J. Hills, University of California, Davis, in analyzing Tests 3-7 and Tests 1 and 2, respectively, is gratefully acknowledged.

#### Tests 1 and 2

These two tests were planted to evaluate our hybrids and lines for bolting tendency. They were planted before the recommended date in the Salinas Valley so that they would be exposed to a longer thermal induction period. 1970-71 was a colder year than normal and a high percentage of the beets bolted.

In two previous years' tests, the experimental equivalent of US H10 and its pollinator, 813, showed more bolting resistance than US H9 and its pollinator, 413. In Test 1, 813 and its Foundation increase, F70-17, continued to show about one-half the bolting percentage of F69-413, but F69-813H4 (US H10A) was more bolting susceptible than either a 1968 or 1969 lot of US H9A. The experimental equivalent of US H10B, 813H8, tended to be more bolting resistant than F69-813H8 (US H10B) or the two seed lots of US H9B. F69-813H8 tended to be more susceptible than either of the two lots of US H9B.

Results of bolting resistance tests with US H10 have been inconsistent so several 1971 seed lots of US H10A and B have been planted in the 1971-72 bolting trials to determine their bolting resistance.

### Test 3

This trial was composed of 16 open-pollinated and 11 three-way hybrids. The open-pollinated lines include the yellows-resistant pollinator parents for US H9 and US H10, lines from the yellows resistance selection program, and two susceptible checks. The three-way hybrids are experimental combinations using one or more components selected for yellows resistance.

The purposes of this test were to evaluate these lines and hybrids for yellows resistance and to determine their performance under both light and severe yellows. Each of the 10 replications was divided into two blocks and one block from each replication was randomly selected and inoculated with a combination of beet yellows virus (BYV) and beet western yellows virus (BWYV). A highly virulent strain of BYV was used, but the virulence of the combination of isolates of BWYV was unknown. Natural yellows infection was light in the noninoculated plots throughout most of the season but became moderate by mid-August.

There was a highly significant difference between virus treatments with the yellows inoculated lines showing an average 33.8% reduction in gross sugar yield and 1% point decrease in sucrose concentration. A significant variety x virus treatment interaction occurred for gross sugar yield, beet yield, and sucrose percentage. This interaction showed that there was a differential response between varieties to virus yellows infection. For example, 813 (C17) had a 31.3% loss for gross sugar yield whereas its parental line, 868, had a 50.4% loss.

Except for the two susceptible checks, 868 and F66-64, the open-pollinated lines generally showed slightly more resistance than the hybrids. When the hybrid and the equivalent of its pollinator line were compared, e.g., Y003H8 and Y003, the hybrid showed an average 3% greater loss for gross sugar yield. For this test there were no consistent differences in resistance between hybrids that had one or more components selected for yellows resistance.

Correlations were run to determine if there was a relationship between the yield of the noninoculated lines and their potential loss to yellows infection. A significant correlation ( $r = .53$ ) was obtained between the sugar percentage in the noninoculated plots and the % loss for sucrose percentage. This suggests that lines with high sucrose concentration are more liable to a greater reduction than lines with a relatively lower sucrose concentration. For beet yield and gross sucrose, the opposite trend was shown, i.e., as the yield increased, there was a tendency for losses due to yellows infection to be less.

At harvest, bolting and rotting were counted. The crown rot count was made visually before the roots were lifted. The root rot count was made while the plots were being weighed. Neither bolting nor rotting was high; however, there were significant variety and virus treatment differences. A significant variety by virus treatment interaction also occurred for root and crown rot. In general, severe yellows infection caused a decrease in bolting and rotting.

#### Test 4

The purposes of this test were to evaluate and compare the performance of commercial and advanced hybrids under light and severe yellows infection and their relative levels of yellows resistance. The procedures were essentially identical to those used in Test 3.

There was a significant difference between virus treatments with the inoculated plots showing an average loss of 37.9% for gross sugar yield and about 1.4% points loss for sucrose concentration. There was not a significant variety x virus interaction for yield.

With the exception of US H7, these hybrids have a pollinator parent that was selected for yellows resistance. The female  $F_1$  hybrids are either 546H3, 569H3, or a cross between self-fertile lines selected for yellows resistance. There was little difference in yellows resistance between the hybrids with 546H3 or 569H3 and those with  $F_1$  hybrids selected for yellows resistance. The difference between the susceptible check, US H7, and the other hybrids was less than usually observed.

US H9A, US H9B, US H10A (F69-813H4), and US H10B (F69-813H8 and 813H8) are commercial hybrids. The sugar yield of the US H9 and US H10 hybrids averaged about the same when noninoculated, but when inoculated, US H10 showed less loss for beet yield and sucrose concentration and averaged about 500 pounds more sugar per acre. From this and other tests, it appears that US H9 and US H10 are very similar, but that US H10 has slightly more yellows resistance.

The results of Tests 3 and 4 indicate that we have developed open-pollinated, multigerm lines that are nearly equal to C413 and 813 (C17) for yellows resistance and combining ability for yield. However, Y04, Y03, and 44 are considered to be too curly top susceptible for general use in California. Y01 has not been adequately tested. Several of the self-fertile lines selected for yellows resistance appeared to be equal to or better for yield than the lines comprising 546H3 or 569H3, but these have other deficiencies, or have not been sufficiently tested.

As with Test 3, there was a significant ( $r = .47$ ) correlation between the sucrose concentration in the noninoculated plots and the % loss for sucrose concentration. There was no correlation between the beet or sugar yield of noninoculated plots and the % loss for beet or sugar yield.

#### Test 5

Several company geneticists expressed an interest in having several of their hybrids evaluated for virus yellows resistance using inoculated and noninoculated blocks. Hybrids from Amalgamated, American Crystal, Holly, Spreckels, and Utah and Idaho Sugar Companies were included in the test along with six U.S.D.A. hybrids.

Half of each replication was inoculated with a combination of BYV and BWYV. The inoculated blocks had essentially 100% infection. The noninoculated blocks had a moderate level of infection by mid-August.

This test probably has poor reliability due to a combination of late planting, irregular distribution of irrigation water, and poor drainage in part of one inoculated block.

#### Test 6

The purpose of this test was to compare the yellows resistance and performance of lines selected for yellows resistance from 868 (US 75). F70-413, 813, and 868 were included as resistant and susceptible checks.

The yellows resistant pollinators of US H9 (C413) and US H10 (C17) were developed by successive mass selections from yellows infected populations originating with US 75. Root weight was used as the primary criterion of selection with the sucrose concentration also being considered in the later selections. C413 was developed after five successive selections and 813 (C17) after eight successive selections.

To determine what progress can be made in a single mass selection and the relative influences of selecting for root weight and sucrose concentration, plants of 868 (US 75) were selected from a BYV-BWYV infected population in 1969. From 2,500 plants, 300 plants were selected from the field on the basis of the largest roots, conformation, and freedom from other diseases and were analyzed for sucrose percentage. On the basis of sucrose percentage and root weight, the beets were divided into three groups. Line 068/2 was produced from about 35 roots that had the highest sucrose concentration. Line 068/3 was produced from about 35 roots that had the highest gross sugar, except those few used to produce 068/2. Line 068/1 was produced from about 35 roots that had the lowest gross sugar.

These lines were compared with 868, 413, and 813 under noninoculated and yellows inoculated conditions. The yellows resistance as measured by percent loss was improved very little and there was only a few percentage points difference between the three lines. The gross sugar selection, 068/3, was significantly improved in sugar and beet yield under both infection conditions. The high sucrose concentration selection, 068/2, was not significantly different for gross sugar or beet yield but had a significantly higher sucrose percentage under both inoculated and noninoculated conditions. The 068/1 selection was not significantly different from 868.

The comparison of 868 with 068/1, 068/2, and 068/3 indicated that in one cycle of mass selection the yield characteristics of 868 can be significantly influenced by the selection criterion, but none of the selection criteria had an appreciable effect on increasing yellows resistance. It is probable that a number of cycles of mass selection,

as used for 413 and 813, is needed to increase the frequency of resistant genes present in susceptible lines and to correctly identify the most resistant segregates. It is also probable that breeding methods that use some form of progeny testing would help identify the most resistant plants and reduce the number of selection cycles needed.

The RS3 and R6 lines were developed by Dr. J. M. Fife. BYV infected US 75 plants were grown in the greenhouse and selected using a combination of root weight and amino acid ratio. In the noninoculated plots, RS3 and R6 showed no change for beet or sugar yield when compared to 868 (US 75) but showed an increased sucrose concentration. In inoculated plots, RS3 and R6 had higher gross sugar yield, beet yield, and sucrose concentration than 868. This test indicated that improvement for yellows resistance was made in these lines.

#### Test 7

In our yellows resistant selection program, a combination of BYV and BWYV has been used to inoculate the plants. The same combination has also generally been used when the selected lines were evaluated for resistance at Salinas or Davis. There is some question whether these lines have resistance to BYV, BWYV, or both. US H7A, US H9B, US H20, and seven open-pollinated lines of more or less diverse origins were compared. Each of the 12 replications was divided into four blocks. One block picked at random from each replication was inoculated with either a combination of BYV-BWYV, BYV, BWYV, or left as a noninoculated check.

The noninoculated plots were moderately infected by late season. Inoculations with BYV and the combination of BYV-BWYV resulted in a high percentage of infection. The BWYV inoculation was unsuccessful. Aphids would not feed on the BWYV beet source plants, and many of the ones that did were infected by a fungus disease.

There was a significant difference between the noninoculated check and the BYV-BWYV and BYV inoculations, but the BWYV inoculation was not significantly different from the check. The BYV-BWYV and BYV inoculations were not significantly different. Previous studies have shown that the effects of BYV and BWYV are additive. The BYV-BWYV inoculation should have caused more yield reduction than the BYV inoculation alone.

When inoculations were made with BYV-BWYV, check inoculations on shepherd's purse showed that BWYV was present. It appears, however, that the isolates of BWYV used in 1971 in the BYV-BWYV source plants caused little damage to beet. Possibly, the aphids that moved into the plot field earlier transmitted BWYV and the plants were already uniformly infected. Shepherd's purse growing in the plot field showed good symptoms of BWYV infection, although distinct yellows symptoms on beet were absent.

There were significant variety x virus treatment interactions for gross sugar yield, beet yield, and sucrose percentage. These interactions indicated that there were differences in yellows resistance within these lines. In this test, the differential effects would have been caused primarily by BYV infection. It is still unknown if these lines differ in BWYV resistance.

TEST 7. VARIANCE TABLE

Source	d.f.	Sugar Yield	Beet Yield	Sucrose %	Beets/ 100 <sup>1</sup>
Replication	11	$442 \times 10^4**$	66.0**	3.50**	1,680
Virus	3	$11,135 \times 10^4**$	912.8**	64.66**	1,412
Error A	33	$30 \times 10^4$	3.5	0.49	799
Variety	9	$628 \times 10^4**$	55.9**	13.17**	5,014**
Variety x Virus	27	$116 \times 10^4**$	10.5**	0.94**	111
Error B	396	$31 \times 10^4$	3.9	0.41	168
Total	479				

\*\*Significant at the 1% level.

## TEST 1. BOLTING EVALUATION TRIAL, SALINAS, CALIFORNIA, 1970-71

5 replications  
1 row plots, 53 ft. long

Variety	Description	Acre Yield			7/6			7/28			9/1			Beets/ 100 <sup>1</sup>	
		Sugar		Beets	Sucrose	Bolting		Bolting	Bolting		Bolting	Percent		Number	
		Pounds	Tons	Percent											
Y003H8	F68-546H3 x Y803	13,120	41.15	16.0	7.9	13.7	18.5	165							
Y004H16B	F68-546H5 x Y904B (716H29 x 7718) x Y904A	12,820	40.17	16.0	10.5	14.7	23.9	160							
Y004H46	F68-546H5 x Y904A	12,570	40.74	15.4	11.6	20.0	30.6	159							
Y004H16	(562H0 x 546) x C813	12,560	39.56	15.9	12.1	18.9	24.3	152							
F69-813H8	(562H0 x 546) x 713A	12,170	39.47	15.4	27.2	37.4	48.4	167							
813H8	(562H0 x 546) x 713A	12,150	37.88	16.1	14.8	24.7	29.6	168							
Y004H8B	F68-546H3 x Y904B	12,150	38.58	15.8	13.2	22.0	32.4	148							
Y004H8	F68-546H3 x Y904A	12,030	37.47	16.1	14.8	22.2	30.0	154							
014H8	F68-546H3 x 814	11,960	38.23	15.7	18.9	26.8	36.1	160							
044H56M	9724H49M x 944	11,620	37.50	15.5	25.6	35.8	45.1	165							
U813H4	US H9A	11,550	37.23	15.6	23.7	33.7	41.9	173							
U813H8	US H9B	11,490	36.47	15.8	22.3	28.2	34.8	176							
F69-813H4	(562H0 x 569) x C813	11,290	35.85	15.8	31.5	41.9	51.0	170							
U913H4	US H9A	11,230	35.52	15.8	26.7	36.0	46.3	173							
044H8	F68-546H3 x 944	11,220	36.50	15.4	14.8	26.7	35.7	151							
014H56M	9724H49M x 814	11,180	35.24	15.9	31.0	45.5	49.7	169							
U913H8	US H9B	11,170	35.41	15.8	23.9	32.2	39.9	162							
Y001H58	(718H32 x 7714) x Y801	11,170	35.24	15.9	28.4	40.2	55.3	162							
Y004H56M	9724H49M x Y904A	10,960	34.40	15.9	23.7	32.7	37.2	158							
F70-813T	Inc. C813T	10,870	35.84	15.2	11.9	16.3	21.3	145							
Y001H8	F68-546H3 x Y801	10,710	34.13	15.7	25.9	37.0	46.7	153							
F70-17	Inc. 8 YRS, 2 SS US 75 (C813)	10,650	34.33	15.5	14.0	20.8	24.8	159							
664H4	(562H0 x 569) x 64 (US H7)	10,590	33.98	15.6	21.8	27.8	37.8	171							
F69-413	Inc. 5 YRS US 75 (C413)	10,550	34.36	15.4	40.4	45.9	52.7	169							
813	Inc. 8 YRS, 2 SS US 75 (713A)	10,520	34.16	15.4	10.0	14.4	21.0	168							
Y001H56M	9724H49M x Y801	10,340	33.22	15.6	33.4	50.0	60.0	145							
F70-13	Inc. 7 YRS, 1 SS US 75 (C713)	10,200	33.33	15.3	32.9	44.0	48.8	166							
014	Inc. 814	10,180	33.29	15.3	30.2	39.5	44.6	167							
664H8	(562H0 x 546) x 64 (US H7A)	9,990	32.15	15.6	24.5	37.0	42.8	160							
868	Inc. F57-68	9,000	29.04	15.5	20.5	26.7	36.4	156							
Mean		11,270	36.02	15.6	21.6	30.4	38.3	162							
LSD (.05)		998	3.28	NS	6.35	6.90	8.02	18.23							
Coefficient of Variation		7.06	7.25	2.98	23.45	18.08	16.70	8.98							
F value		6.91**	5.53**	1.40	13.78**	17.68**	15.02**	1.67*							

\*Exceeds the 5% point of significance (F=1.63)  
\*\*Exceeds the 1% point of significance (F=1.98)

## TEST 2. BOLTING EVALUATION TRIAL, SALINAS, CALIFORNIA, 1970-71

4 replications  
1 row plots, 32 ft. longPlanted: November 19, 1970  
Harvested: September 14, 1971

Variety	Description	Acre Yield		7/6		7/28		9/1		Beets/ 100 <sup>1</sup>	Number
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting Percent	Bolting Percent	Bolting Percent	Bolting Percent	Bolting Percent		
<u>3-way Hybrids</u>											

044H46	(716H29 x 7718) x 944	12,970	41.81	15.5	8.8	18.7	30.5	156			
Y004H12B	F68-546H4 x Y904B	12,720	39.64	16.0	13.9	21.3	30.6	177			
Y004H12	F68-546H4 x Y904A	12,710	40.69	15.6	12.1	19.2	29.2	174			
044H12	F68-546H4 x 944	12,700	41.22	15.4	9.4	18.7	29.5	166			
Y001H16	F68-546H5 x Y801	12,470	39.51	15.8	19.0	27.2	37.3	176			
Y004H4	F67-569H3 x Y904A	12,260	38.92	15.8	17.5	25.1	31.0	167			
Y904H4	F64-569H3 x Y804	12,220	39.58	15.5	25.7	37.5	50.1	164			
044H16	F68-546H5 x 944	12,050	39.31	15.3	17.2	27.3	38.7	168			
Y004H49	(716HO x 7760) x Y904A	11,600	37.02	15.7	25.7	38.0	45.3	173			
014H4	F67-569H3 x 814	11,470	35.97	15.9	32.3	38.8	48.3	167			
Y001H49	(716HO x 7760) x Y801	11,130	35.70	15.6	37.9	53.9	64.8	173			
Y001H4	F67-569H3 x Y801	11,090	36.13	15.4	33.5	45.6	54.6	174			
Y004H57	(760H29 x 7714) x Y904A	11,030	36.13	15.3	34.6	43.0	55.0	173			

Open-pollinated Lines

0105	F2B1 (mm x Y04)	12,170	39.67	15.3	21.4	37.6	47.2	172			
Y003	Inc. Y803	12,100	37.61	16.1	6.4	12.6	21.2	166			
044	Inc. 944	11,630	38.92	14.9	17.9	35.7	51.1	163			
0110	F2B1 (mm x 44)	11,430	37.34	15.3	27.2	39.1	48.2	164			
013B	Inc. 8 YRS US 75 (713B)	11,360	37.54	15.2	13.6	20.9	29.2	173			
Y004B	Inc. Y904B	11,000	36.29	15.2	15.2	23.1	29.1	170			
Y022	Inc. 9111	10,950	36.52	15.0	19.1	21.7	32.8	155			
813T	Inc. 713T	10,940	38.07	14.4	10.1	16.3	19.1	112			
Y004	Inc. Y904A	10,900	35.24	15.5	14.2	21.0	32.2	161			
013A	Inc. 6 YRS US 75 (413A)	10,890	36.79	14.8	22.8	34.0	43.4	172			
0107	F2B1 (mm x 13)	10,890	35.90	15.2	25.5	30.6	43.0	167			
0104	F2B1 (mm x Y03)	10,780	33.74	16.0	18.8	33.8	48.2	166			
F69-713	Inc. 7 YRS, 1 SS US 75 (G713)	10,760	35.97	15.0	36.6	48.1	49.8	175			
Y001	Inc. Y801	10,570	34.69	15.3	38.9	49.2	61.3	161			
F68-613	Inc. 7 YRS US 75 (C613)	10,410	36.13	14.4	20.1	29.1	34.9	173			

## TEST 2. BOLTING EVALUATION TRIAL, SALINAS, CALIFORNIA, 1970-71 continued

- B15 -

Variety	Description	Acre Yield		7/6		7/28		9/1		Beets/ Number
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting Percent	Bolting Percent	Bolting	Bolting	Bolting	
0103	F <sub>2</sub> B <sub>1</sub> (mm x Y02)	10,320	33.70	15.3	13.5	19.6	31.2	169		
Y904	Inc. Y804	10,230	34.92	14.7	30.2	41.3	51.6	168		
F66-64	Inc. 264	10,220	33.57	15.2	20.8	29.3	36.1	166		
Y001A	YRS Y801	10,070	32.95	15.3	41.5	49.5	66.7	163		
0106	F <sub>2</sub> B <sub>1</sub> (mm x 10)	10,060	32.55	15.5	24.5	45.5	51.8	163		
Y001B	YRS Y801 Sp.	10,000	32.29	15.5	50.2	68.1	69.9	158		
959	Inc. 659 (US 56/2)	9,070	29.83	15.2	31.0	40.3	49.5	161		
0102	F <sub>2</sub> B <sub>1</sub> (mm x Y01)	8,540	27.89	15.3	68.2	68.2	84.8	166		

F<sub>1</sub> Hybrids

7718H32	6716H29 x 7718	12,240	41.61	14.7	6.6	12.7	24.6	180		
7718H31	6705H25 x 7718	11,940	37.71	15.9	21.7	31.8	43.9	177		
0724H5	F68-564HO x 9724	11,030	35.41	15.6	23.1	32.0	43.3	174		
0724H52	8522H1 x 9724	10,710	34.26	15.6	14.0	22.8	29.8	179		
0724H55	9714HO x 9724	10,360	32.49	15.9	20.3	29.3	37.0	173		
0724H54A	9705HOA x 9724	10,270	32.29	15.9	17.6	26.3	31.9	169		
9714H46	7718H32 x 7714	10,220	33.47	15.3	31.4	45.4	62.9	167		
0705H56M	9724H49M x 9705	10,130	32.32	15.7	36.7	53.5	57.5	173		
0724H57	9714H40 x 9724	10,090	32.75	15.4	16.1	26.9	38.6	166		
0705H52	8522H1 x 9705	10,000	31.73	15.8	26.9	41.4	47.4	160		
0705H53	8522H2 x 9705	9,870	31.11	15.9	36.9	49.8	58.9	170		
0724H56M	9724H49M x 9724	9,780	31.37	15.6	16.3	28.3	36.7	171		
0724H54B	9705HOB x 9724	9,450	29.67	15.9	21.8	31.6	36.5	166		
0705H5	F68-564HO x 9705	9,270	29.96	15.5	44.4	59.0	69.1	170		
8522H2	7601H2 x 8522	8,510	26.91	15.8	53.8	69.2	74.9	164		
8522H1	5564HO x 8522	7,820	25.01	15.7	48.9	56.9	64.4	149		

Mean	10,840	35.15	15.4	25.2	35.5	44.9	167			
LSD (.05)	1,070	3.19	0.69	9.20	10.81	11.59	14.99			
Coefficient of Variation	7.07	6.50	3.19	26.11	21.80	18.48	6.43			
F value	9.04**	11.03**	2.61**	15.46**	13.65**	12.52**	3.48**			

\*\*Exceeds the 1% point of significance (F=1.66)

## TEST 3. VARIETY X VIRUS YELLOWS TRIAL, SALINAS, CALIFORNIA, 1971

10 replications  
2 virus treatments  
1 row plots, 53 ft. long

Planted: January 28, 1971  
Inoculated: April 29, 1971  
Harvested: September 21, 1971

Variety	Description	Sugar Yield (lb/A)			Beet Yield (Tons/A)		
		Check	Inoc.	% Loss	Check	Inoc.	% Loss
Y003H8	546H3 x Y803	12,300	8,610	29.6	38.72	28.22	26.7
044H56mm	(760H33 x 724) x 944	12,130	8,260	31.9	39.57	28.34	28.4
044H16	546H5 x 944	12,100	8,030	33.8	38.58	27.06	30.0
Y004H16B	546H5 x Y904B	12,040	8,140	32.6	38.78	27.69	28.8
Y001H16	546H5 x Y801	11,900	7,720	35.1	37.59	26.26	30.2
Y001A	YRS Y801	11,880	7,800	34.2	36.68	26.15	28.6
Y004H16	546H5 x Y904A	11,810	7,870	33.3	37.67	26.85	28.7
Y001H58	(718H32 x 714) x Y801	11,800	7,700	34.7	36.79	26.26	28.6
Y004H57	(760H29 x 714) x Y904A	11,790	7,490	36.4	37.21	25.74	30.7
Y004H56mm	(760H33 x 724) x Y904A	11,770	7,700	34.5	37.52	26.35	29.7
014H56mm	(760H33 x 724) x 814	11,520	7,490	35.1	36.74	25.23	31.3
Y001H56mm	(760H33 x 724) x Y801	11,460	7,260	36.6	36.10	24.76	31.3
044	944	11,450	8,060	29.7	36.99	27.83	24.8
Y904 Spence	Inc. Y804	11,300	8,050	28.8	36.77	27.81	24.5
Y001B	YRS Y801 Spence	11,230	8,170	27.2	34.44	26.59	22.8
Y003	Inc. Y803	11,190	8,170	26.6	34.30	26.72	21.7
Y022	Inc. 9111	11,030	7,770	29.6	35.46	26.81	24.4
Y001	Inc. Y801	10,990	6,690	39.2	34.34	23.00	33.0
014	Inc. 814	10,810	6,960	35.6	34.12	23.30	31.8
Y004	Inc. Y904A	10,670	7,410	30.6	34.15	25.37	25.5
Y004B	Inc. Y904B	10,610	7,690	27.5	34.02	26.34	22.6
F70-413	Inc. C413	10,240	6,800	33.8	33.29	23.31	30.1
813 Spence	Inc. 713A	10,230	7,010	31.3	32.30	23.45	27.3
F70-17	Inc. C813	10,190	6,890	32.5	32.25	22.84	29.2
F70-813T	Inc. C813T	9,760	6,270	35.7	33.07	21.91	33.7
F66-64	Inc. 264	9,230	4,980	45.8	29.63	17.51	40.8
868	Inc. F57-68 (US 75)	8,910	4,390	50.4	28.51	15.65	44.9
Mean		11,120	7,380	33.8	35.39	25.09	29.3
LSD (.05)		680	680	6.71	2.14	2.14	6.58
Coefficient of Variation		7.0	10.5	22.6	6.9	9.7	25.6
F value		26.80**	26.80**	4.69**	26.54**	26.54**	4.54**

\*\*Exceeds the 1% level of significance.

## TEST 3. VARIETY x VIRUS YELLOWS TRIAL, SALINAS, CALIFORNIA, 1971 continued

10 replications  
2 virus treatments  
1 row plots, 53 ft. long

Planted: January 28, 1971  
Inoculated: April 29, 1971  
Harvested: September 21, 1971

Variety	Description	% Sucrose		Beets/ 100' Number	Bolting Percent	Root Rot Percent	Crown Rot Percent
		Check	Inoc.				
Y003H8	546H3 x Y803	15.9	15.3	4.0	144	0.14	0.07
	(760H33 x 724) x 944	15.3	14.6	4.9	138	0.29	0.07
044H56mm	546H5 x 944	15.7	14.8	5.5	137	0.27	0.07
044H16	546H5 x Y904B	15.5	14.7	5.4	141	0.00	0.07
Y004H16B	546H5 x Y801	15.8	14.7	6.9	134	0.15	0.30
Y001H16	YRS Y801	16.2	14.9	7.9	141	1.97	0.06
Y004H16	546H5 x Y904A	15.7	14.6	6.5	135	0.06	0.43
Y001H58	(718H32 x 714) x Y801	16.0	14.7	8.5	133	0.41	0.12
Y004H57	(760H29 x 714) x Y904A	15.8	14.5	8.2	134	0.00	0.07
Y004H56mm	(760H33 x 724) x Y904A	15.7	14.6	6.9	136	0.15	0.07
014H56mm	(760H33 x 724) x 814	15.7	14.8	5.6	139	0.13	0.07
Y001H56mm	(760H33 x 724) x Y801	15.9	14.7	7.8	136	0.65	0.29
044	Inc. 944	15.5	14.5	6.6	135	0.21	0.15
Y904 Spence	Inc. Y804	15.4	14.5	5.6	141	0.13	0.96
Y001B	YRS Y801 Spence	16.3	15.3	5.9	130	0.64	0.00
Y003	Inc. Y803	16.3	15.2	6.5	132	0.37	0.00
Y022	Inc. 9111	15.6	14.5	6.8	140	0.20	0.56
Y001	Inc. Y801	16.0	14.5	9.5	125	0.98	0.00
014	Inc. 814	15.8	14.9	5.5	143	0.06	0.69
Y004	Inc. Y904A	15.6	14.6	6.7	136	0.07	0.59
Y004B	Inc. Y904B	15.6	14.6	6.3	136	0.22	0.00
F70-413	Inc. C413	15.4	14.6	5.2	136	0.00	0.49
813 Spence	Inc. 713A	15.8	15.0	5.6	140	0.00	1.39
F70-17	Inc. C813	15.8	15.1	4.7	136	0.00	0.00
F70-813T	Inc. C813T	14.7	14.3	2.9	122	0.00	1.63
F66-64	Inc. 264	15.6	14.2	8.6	147	0.19	0.00
868	Inc. F57-68 (US 75)	15.6	14.0	10.0	138	0.07	0.00
Mean		15.71	14.69	6.5	136	0.27	0.30
LSD (.05)		0.37	0.37	2.55	4.0	0.41	0.53
Coefficient of Variation		2.7	2.9	44.7	4.7	247.00	204.00
F value		9.18**	9.18**	3.16**	13.7**	7.65**	7.27**

\*\*Exceeds the 1% level of significance.

## TEST 4. VARIETY x VIRUS YELLOWS TRIAL, SALINAS, CALIFORNIA, 1971

10 replications  
2 virus treatments  
2 row plots, 53 ft. long

Planted: January 29, 1971  
Inoculated: April 28, 1971  
Harvested: September 28, 1971

Variety	Description	Sugar Yield (lb/A)			Beet Yield (Tons/A)		
		Check	Inoc.	% Loss	Check	Inoc.	% Loss
Y004H46	(716H29 x 718) x Y904A	11,300	6,900	39.1	34.76	24.18	30.7
Y904H45	(705H24 x 718) x Y804	10,950	6,900	36.9	34.42	22.91	33.3
813TH32	(754HO x 716) x 713T	10,940	6,780	38.2	34.98	23.19	33.8
044H46	(716H29 x 718) x 944	10,720	6,520	39.3	34.12	23.00	32.7
Y004H8	546H3 x Y904A	10,710	6,950	35.1	32.32	23.16	28.1
044H8	546H3 x 944	10,700	6,850	35.8	33.06	23.08	30.1
Y904H8	546H3 x Y804	10,670	7,010	34.2	33.22	23.25	30.0
813TH49	(716HO x 760) x 713T	10,560	6,500	38.6	32.66	21.90	33.1
Y004H8B	546H3 x Y904B	10,560	7,080	32.8	32.48	23.64	27.1
U913H8	546H3 x F68-413 (US H9B)	10,470	6,520	37.8	32.13	21.88	31.9
Y001H8	546H3 x Y801	10,430	6,400	38.8	31.86	21.31	33.2
813H45	(705H24 x 718) x 713A	10,420	6,770	34.6	32.13	22.44	29.8
813H32A	(754HO x 716) x F66-13	10,400	6,320	38.7	32.64	21.70	33.0
F69-813H8	546H3 x C813	10,350	6,570	36.6	31.47	21.69	31.1
014H8	546H3 x 814	10,340	6,380	38.3	31.16	21.27	31.7
014H4	569H3 x 814	10,100	5,950	41.1	30.60	20.01	34.7
813H8	546H3 x 713A	10,050	6,710	33.1	30.84	22.49	26.8
813H49A	(716HO x 760) x F66-13	10,000	6,070	39.1	31.22	20.23	34.9
U913H4	569H3 x F68-413 (US H9A)	9,830	5,470	44.3	30.61	18.84	38.5
F69-813H4	569H3 x C813	9,600	6,160	35.8	29.09	20.37	29.8
664H4	569H3 x 664 (US H7)	9,200	4,890	46.7	28.32	16.93	40.0
Mean		10,390	6,460	37.9	32.10	21.78	32.1
LSD (.05)		686	686	5.47	2.22	2.22	5.72
Coefficient of Variation		7.5	12.1	16.5	7.9	11.6	20.3
F value		7.70**	7.70**	2.94**	8.63**	8.63**	2.55**

\*\*Exceeds the 1% level of significance.

TEST 4. VARIETY x VIRUS YELLOWS TRIAL, SALINAS, CALIFORNIA, 1971 continued

10 replications  
2 virus treatments  
2 row plots, 53 ft. long

Variety	Description	% Sucrose			Beets / 100' Number	Bolting Percent	Root Rot Percent
		Check	Inoc.	% Loss			
Y004H46	(716H29 x 718) x Y904A	16.3	14.3	12.2	124	.00	.57
Y904H45	(705H24 x 718) x Y804	15.9	15.0	5.5	137	.13	.13
813TH32	(754HO x 716) x 713T	15.6	14.6	6.5	135	.14	.18
044H46	(716H29 x 718) x 944	15.7	14.2	9.9	129	.00	.17
Y004H8	546H3 x Y904A	16.6	15.0	9.4	131	.04	.32
044H8.	546H3 x 944	16.2	14.8	8.2	134	.07	.00
Y904H8	546H3 x Y804	16.1	15.1	6.0	130	.04	.14
813TH49	(716HO x 760) x 713T	16.2	14.9	8.0	118	.00	.12
Y004H8B	546H3 x Y904B	16.2	15.0	7.8	136	.07	.07
U913H8	546H3 x F68-413 (US H9B)	16.3	14.9	8.7	138	.03	.07
Y001H8	546H3 x Y801	16.4	15.0	8.4	135	.22	.00
813H45	(705H24 x 718) x 713A	16.2	15.1	6.8	131	.00	.13
813H32A	(754HO x 716) x F66-13	15.9	14.6	8.4	127	.00	.19
F69-813H8	546H3 x C813	16.5	15.1	7.9	144	.03	.07
014H8	546H3 x 814	16.6	14.9	9.9	136	.00	.00
014H4	569H3 x 814	16.5	14.9	9.8	136	.00	.06
813H8	546H3 x 713A	16.3	14.9	8.5	139	.00	.11
813H49A	(716HO x 760) x F66-13	16.0	15.0	6.4	127	.07	.03
U913H4	569H3 x F68-413 (US H9A)	16.0	14.5	9.5	141	.00	.00
F69-813H4	569H3 x C813	16.5	15.1	8.5	142	.18	.14
664H4	569H3 x 664 (US H7)	16.3	14.5	10.7	148	.07	.00
Mean		16.21	14.83	8.4	134	0.05	0.12
LSD (.05)		0.45	0.45	3.17	5.7	0.12	0.21
Coefficient of Variation		3.7	3.5	43.1	6.9	395.00	314.00
F value		4.28**	4.28**	2.05**	11.8**	2.19**	2.93**

\*\*Exceeds the 1% level of significance.

## TEST 5. COMPANY VARIETIES X VIRUS YELLOWS TRIAL, SALINAS, CALIFORNIA, 1971

5 replications  
2 virus treatments  
1 row plots, 53 ft. long

Planted: May 5, 1971  
Inoculated: June 29, 1971  
Harvested: October 12, 1971

- B20 -

Variety	Description	Sugar Yield (1b/A)			Beet Yield (Tons/A)			% Sucrose			Beets / 100' Number
		Check	Inoc.	% Loss	Check	Inoc.	% Loss	Check	Inoc.	% Loss	
ACS-2	S9735	4,100	2,180	46.8	13.81	8.34	39.6	14.9	13.1	12.1	145
Amal.-2	E0218, (MS x C813)	3,920	2,320	40.8	12.95	8.27	36.1	15.2	14.1	7.2	152
ACS-1	S9733	3,710	2,500	32.6	12.63	9.26	26.7	14.7	13.5	8.2	140
044H8	546H3 x 944	3,710	2,700	27.2	12.51	9.89	20.9	14.8	13.6	8.1	134
Y004H8	546H3 x Y904A, B	3,700	2,610	29.5	12.44	9.43	24.2	14.9	13.8	7.4	143
Amal.-1	E0208, (MS x C413)	3,660	2,140	41.5	12.13	7.85	35.3	15.1	13.5	10.6	156
U & I-3	U & I #G	3,650	2,260	38.1	12.89	8.40	34.8	14.2	13.4	5.6	148
Holly-2	03126-02	3,630	2,570	29.2	12.82	9.68	24.5	14.2	13.2	7.0	154
Amal.-3	E0200, (MS x C904)	3,610	2,500	30.7	11.99	9.02	24.8	15.1	13.9	7.9	153
813H8	546H3 x 713A (US H10)	3,510	2,610	25.6	11.90	9.34	21.6	14.7	14.0	4.8	153
U813H8	546H3 x C413 (US H9B)	3,460	2,350	32.1	11.71	8.70	25.7	14.8	13.5	8.8	163
Spreck.-2	S-101H12	3,440	1,550	54.9	11.18	5.71	48.9	15.3	13.3	13.1	143
Holly-1	03124-07	3,340	2,260	32.3	11.13	8.23	26.1	15.0	13.7	8.7	160
U & I-2	U & I #F	3,340	1,900	43.1	11.29	7.17	36.6	14.8	13.3	10.1	139
Spreck.-1	H691188	3,250	1,680	48.3	11.00	6.32	42.5	14.8	13.3	10.1	151
U & I-1	U & I #D	2,990	1,730	42.1	9.41	6.33	32.7	15.9	13.7	13.8	151
813H50	705H30 x 713A	2,990	2,550	14.7	9.92	8.91	10.2	15.1	14.3	5.3	156
664H8	546H3 x 664 (US H7A)	2,640	1,720	34.8	8.94	6.39	28.5	14.8	13.5	8.8	151
Mean		3,480	2,230	35.9	11.70	8.18	30.0	14.9	13.6	8.8	150
LSD (.05)		662	662	--	2.18	2.18	--	0.64	0.64	--	6.6
Coefficient of Variation		15.2	23.7	--	14.9	21.3	--	3.4	3.7	--	5.0
F value		3.4**	3.4**	--	4.4**	4.4**	--	3.2**	3.2**	--	10.1**

\*\*Exceeds the 1% point of significance.

## VARIANCE TABLES

## TEST 3

Source	d.f.	Sugar Yield	Beet Yield	Sucrose %	Beets / 100 <sup>1</sup>	Bolting %	Root Rot %	Crown Rot %
Replication	9	86 x 10 <sup>5</sup> **	114.5**	0.83	4,511**	0.28	1.02	1.54
Virus	1	18,879 x 10 <sup>5</sup> **	14,334.4**	141.70**	3,193	4.64**	8.90**	16.63**
Error A	9	6 x 10 <sup>5</sup>	8.2	0.33	629	0.35	0.49	1.41
Variety	26	161 x 10 <sup>5</sup> **	157.6**	1.68**	558**	3.40**	3.77**	6.13**
Variety x Virus	26	11 x 10 <sup>5</sup> **	10.1*	0.36**	71*	0.43	1.22*	1.34*
Error B	468	6 x 10 <sup>5</sup>	5.9	0.18	41	0.44	0.74	0.84
Total	539							

## TEST 4

Replication	9	25 x 10 <sup>5</sup>	46.9*	2.96*	3,710**	0.009	0.23
Virus	1	16,237 x 10 <sup>5</sup> **	11,172.0**	199.2**	402	0.335**	2.17**
Error A	9	10 x 10 <sup>5</sup>	10.3	.89	690	0.037	0.12
Variety	20	47 x 10 <sup>5</sup> **	55.2**	1.12**	994**	0.086**	0.35**
Variety x Virus	20	4 x 10 <sup>5</sup>	4.9	0.37	52	0.056	0.33**
Error B	360	6 x 10 <sup>5</sup>	6.4	0.26	85	0.039	0.12
Total	419						

## TEST 5

Replication	4	152 x 10 <sup>4</sup>	20.6*	0.36	1,491
Virus	1	7,042 x 10 <sup>4</sup> **	558.7**	75.08**	503
Error A	4	27 x 10 <sup>4</sup>	2.7	0.11	236
Variety	17	96 x 10 <sup>4</sup> **	13.3**	0.81**	563**
Variety x Virus	17	33 x 10 <sup>4</sup>	3.3	0.41	40
Error B	136	28 x 10 <sup>4</sup>	3.0	0.26	56
Total	179				

\* and \*\* Significant at the 5% and 1% levels, respectively.

TEST 6. VARIETY X VIRUS TRIAL, SALINAS, CALIFORNIA, 1971

5 replications

2 virus treatments  
1 row plots, 53 ft. long

Variety	Description	Sugar Yield (1b/A)			Beet Yield (Tons/A)			% Sucrose			Beets/ 100' Number
		Check	Inoc.	% Loss	Check	Inoc.	% Loss	Check	Inoc.	% Loss	
068/3	YRS 868 (high gross sugar)	3,940	2,120	46.3	13.20	7.91	40.1	14.9	13.4	10.1	144
F70-413	Inc. C413	3,720	2,590	30.4	12.32	9.32	24.4	15.0	13.9	7.3	143
068/2	YRS 868 (high % sucrose)	3,610	2,070	42.6	11.72	7.50	36.0	15.4	13.8	10.4	142
813	Inc. 713A	3,510	2,800	20.4	11.33	9.56	15.6	15.4	14.6	5.2	154
011B	YRS 711	3,380	1,830	45.8	11.59	6.81	41.2	14.6	13.4	8.2	112
Fife's RS3	93-RS3-C	3,340	2,200	34.2	10.64	7.75	27.2	15.7	14.2	9.6	156
Fife's R6	614-R6-C	3,300	2,040	38.1	10.72	7.27	32.2	15.4	14.0	9.1	136
011A	YRS 911C2	3,270	2,130	34.9	10.53	7.51	28.7	15.5	14.1	9.0	135
868	Inc. F57-68 (US 75)	3,220	1,650	48.6	11.03	6.44	41.6	14.5	12.9	11.0	140
068/1	YRS 868 (small, low % sucrose)	3,200	1,770	44.7	11.24	7.13	36.6	14.2	12.4	12.7	141
Mean		3,450	2,120	38.6	11.43	7.72	32.4	15.1	13.7	9.3	140
I.S.D. (.05)		476	476	--	1.54	1.54	--	0.46	0.46	--	10.6
Coefficient of Variation		10.9	17.7	--	10.7	15.8	--	2.4	2.7	--	8.4
F value		4.7**	4.7**	--	3.8**	3.8**	--	24.3**	24.3**	--	10.3**

\*\*Exceeds the 1% point of significance.

VARIANCE TABLE

	d.f.	Sugar Yield	Beet Yield	Sucrose %	Beets/ 100'
Replication	4	77 x 10 <sup>5</sup> *	86.5**	0.18	1,029*
Virus	1	442 x 10 <sup>5</sup> **	344.1**	48.09**	237
Error A	4	5 x 10 <sup>5</sup>	3.5	0.34	73
Variety	9	7 x 10 <sup>5</sup> **	5.6**	3.23**	1,438**
Variety x Virus	9	2 x 10 <sup>5</sup>	2.9	0.23	63
Error B	72	1 x 10 <sup>5</sup>	1.5	0.13	139
Total	99				

\* and \*\* Significant at the 5% and 1% levels, respectively.

## TEST 7. VARIETY X VIRUS TRIAL, SALINAS, CALIFORNIA, 1971

12 replications  
4 virus treatments  
1 row plots, 32 ft. long

Planted: May 7, 1971  
Inoculated: May 30, 1971  
Harvested: October 15, 1971

Sugar Yield (lb/A)<sup>1</sup>

Variety	Description	Sugar Yield (lb/A) <sup>1</sup>			Sugar Yield Loss (%) BYV-BWYV	Sugar Yield Loss (%) BYV
		Check	BYV-BWYV	BWYV		
Bush Mono A	From Ellerton	5,040	2,930	5,020	41.9	41.9
U813H8	US H9B (Lot 8226)	4,920	3,160	3,100	4,850	35.8
US H20	(129 x 133)MS x SP6322-0	4,900	2,310	2,350	4,770	52.9
664H8	US H7A (Lot 6210)	4,900	2,570	2,620	4,440	47.6
Y001A, B	YRS Y801	4,850	3,520	3,310	4,920	27.4
Y803	Inc. Y603	4,710	3,430	3,150	4,590	27.2
Y004	Inc. Y904A, B	4,550	3,600	3,140	4,510	20.9
F70-413	Inc. C413 (Lot 0268)	4,340	2,820	2,550	4,220	35.0
868	Inc. F57-68 (US 75)	4,100	1,940	2,230	3,720	52.7
813	Inc. 713A	3,650	3,000	2,930	3,900	17.8
Mean		4,597 <sup>a</sup>	2,929 <sup>b</sup>	2,831 <sup>b</sup>	4,494 <sup>a</sup>	36.3
LSD (.05)		448	448	448	448	38.4
Coefficient of Variation		12.2	19.1	19.8	12.5	2.2
F value		20.1**	20.1**	20.1**	20.1**	---

Variety	Beet Yield (Tons/A)			Beet Yield			% Sucrose BYV-BWYV	% Sucrose BYV	Beets/ 100! Number
	Check	BYV-BWYV	BWYV	Loss (%) BYV-BWYV	Check	BYV-BWYV			
Bush Mono A	17.01	11.05	10.69	17.08	35.0	14.8	13.3	13.7	10.1
U813H8	16.41	11.87	11.35	16.37	27.6	15.0	13.3	13.7	14.7
US H20	15.89	8.83	9.00	16.12	44.4	15.4	12.9	13.1	14.8
664H8	15.97	9.64	9.59	14.83	39.4	15.4	13.4	13.7	15.0
Y001A, B	16.30	12.55	12.03	16.56	23.0	15.0	14.1	13.9	14.9
Y803	14.96	11.69	10.85	14.59	21.9	15.8	14.7	14.6	15.8
Y004	15.29	13.04	11.30	15.55	14.7	14.9	13.9	13.9	14.6
F70-413	15.12	10.75	9.67	14.97	28.9	14.4	13.1	13.2	14.2
868	14.40	7.89	8.68	13.78	45.2	14.3	12.4	12.9	13.5
813	12.14	10.61	10.16	13.22	12.3	15.1	14.2	14.4	14.8
Mean	15.35 <sup>a</sup>	10.79 <sup>b</sup>	10.33 <sup>b</sup>	15.31 <sup>a</sup>	29.7	15.0 <sup>a</sup>	13.5 <sup>c</sup>	13.7 <sup>c</sup>	14.7 <sup>b</sup>
LSD (.05)	1.59	1.59	1.59	1.59	--	0.52	0.52	0.52	--
C.V.	12.9	18.4	19.2	13.0	--	4.3	4.8	4.7	4.4
F value	14.2**	14.2**	14.2**	14.2**	--	31.8**	31.8**	31.8**	29.9**

\*\*Exceeds the 1% level of significance.

<sup>1</sup>/Means with same letter are not significantly different at the 1% level.

NEMATODE WILTING TEST, SALINAS, CALIFORNIA, 1971

(10 replications of each variety)

Planted: May 20, 1971  
Harvested: November 3, 1971

Variety	Description	Acre Yield			Harvest	
		Sugar Pounds	Beets Tons	Sucrose Percent	Count Number	Wilting Grade 1/
0104	(Sel. from RW 467)	3,740	10.67	17.6	133	3.3
RW 667	(Sel. from H. Rietberg)	3,640	10.40	17.5	141	4.8
4502	(Sel. from Acc 107)	2,660	7.96	16.6	139	5.5
Acc 107	(Sel. from G. J. Curtis)	2,480	7.58	16.3	102	5.5
US H9B	(Commercial variety)	2,360	7.48	15.7	141	5.6
2507	(Sel. from Acc 107)	2,350	7.58	15.4	118	5.4
5409	(Sel. from Acc 107)	2,310	6.78	17.1	114	5.9
7701	(Sel. from 590-9)	2,310	7.60	15.1	133	5.0
1108	(Sel. from Acc 107)	2,170	7.20	15.0	120	5.5
6904	(Sel. from Acc 107)	2,120	6.99	15.0	125	5.9
Mean		2,610	8.02	16.1		Beets
LSD (.05)		419	1.24	0.94		per
Coefficient of Variation		18.01	17.37	6.57		100'
F value		15.56**	9.60**	9.31**		row

\*\*Exceeds the 1% point of significance (F=2.64)

1/ 1 = No wilting, 10 = Severe wilting

VARIETY TRIALS, BRAWLEY, CALIFORNIA, 1970-71

Location: U.S. Department of Agriculture, Southwestern Irrigation Field Station.<sup>1/</sup>  
Soil type: Holtville silty clay loam.  
Previous crops: Sugarbeets, 1967-68; barley, 1968-69 and 1969-70.  
Fertilizers used: Preplant: 200 lbs. per acre (/A) 11:48:0, broadcast before listing. Sidedressing: 180 lbs./A actual N, as ammonium nitrate, on October 13-14, 1970.  
Herbicide used: Roneet preplant at 4 lbs./A incorporated in a 10-inch band on the bed.  
Planting date: September 15-17, 1970.  
Thinning date: October 5, 1970.  
Harvest dates: Early harvests: Tests 8 and 9, April 27-28, 1971.  
Midseason harvest: Test 10, June 7, 1971.  
Late harvest: Test 11, July 22, 1971.  
Irrigations: Early harvest - seven by furrow.  
Midseason harvest - nine by furrow.  
Late harvest - twelve by furrow.

Diseases and insects: Yellows infection was moderately light during 1971. Curly top infection was minor. A 5% Sevin bait, at 28 lbs./A was applied September 22, 1970, for the control of cutworm. Infestations of desert flea beetle, striped cucumber beetle, and crickets were controlled with spray applications of 12 oz./A Ethyl-parathion on September 22 and with 10 oz./A 6.3 Monsanto formulation on September 30, 1970. Armyworms were controlled with five spray applications of Lannate (8 oz./A) plus Ethyl-parathion, Ethyl-methyl-parathion, or 6.3 Monsanto between October 3 and November 20, 1970. An application of 10% Thimet granules (12.5 lbs./A) was made on January 27, 1971, for control of green peach aphid. An application of Kelthane (1.0 lb./A) was made on May 22, 1971, for control of red spider mite.

Experimental design: All yield trials were of randomized block design with 10 replications each. Test 8 had 15 entries; Test 9, 12 entries; Test 10, 12 entries; and Test 11, 10 entries. All tests had two-row plots 40 feet long with rows spaced 30 inches apart.

Sugar analysis: From two ten-beet samples per plot for all trials by Holly Sugar Corporation, Brawley, California.

Remarks: Test designed by the U.S. Agricultural Research Station, Salinas, California. All yield data were analyzed by K. D. Beatty.

1/ All sugarbeet trials under supervision of K. D. Beatty at the Southwestern Irrigation Field Station, Brawley, California.

VARIETY TEST, BRAWLEY, CALIFORNIA, 1971

Test 8

(10 replications each variety)  
(Two-row plots)

Planted: September 15, 1970  
Harvested: April 27, 1971

Variety	Description	Acre Yield				Harvest Count
		Sugar Pounds	Beets Tons	Sucrose Percent	Bolting Percent	
044H46	(716H29x718)x 944	9,320	31.11	14.99	0.2	126
Y004H46	(716H29x718)xY904A	9,100	30.61	14.92	0.4	126
Y904H45	(705H25x718)xY804	8,950	29.73	15.06	0.6	129
Y004H8	546H3xY904A	8,630	28.30	15.26	0.8	128
USH10A	569H3 x C813	8,610	28.47	15.14	0.1	128
Y001H8	546H3 x Y801	8,600	27.73	15.55	0.5	131
014H4	569H3 x 814	8,560	27.83	15.41	0.0	126
USH9B	546H3 x 413	8,560	28.42	15.06	0.3	129
USH10B	546H3 x C813	8,550	28.74	14.90	0.4	129
USH9A	569H3 x 413	8,460	28.13	15.06	0.0	129
014H8	546H3 x 814	8,460	27.51	15.36	0.2	130
Y904H8	546H3 x Y804	8,440	27.52	15.34	0.3	126
USH7A	546H3 x 664	8,130	26.13	15.58	0.2	125
014H56M	(760H33x724)x814	8,110	27.20	14.93	1.0	128
USH7	569H3 x 664	8,020	26.65	15.06	0.0	128
Mean		8,570	28.27	15.17	---	Beets
LSD (0.05)		439	1.68	0.41	---	per
Coefficient of Variation-%		5.78	6.73	3.04	---	100'
F value		5.06**	5.12**	2.43**	---	row

\*\* Exceeds the 1% point of significance (F=2.21)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1971

Test 9

(10 replications each variety)  
(Two row plots)

Planted: September 15, 1970  
Harvested: April 28, 1971

Variety	Description	Acre Yield				Harvest Count
		Sugar Pounds	Roots Tons	Sucrose Percent	Bolting Percent	
US H9B	546H3x413	9,480	32.10	14.80	0.4	134
Y001	Incr. Y801	9,230	31.59	14.62	3.1	122
Y001 A,B	YRS Y801	9,160	30.85	14.84	4.9	124
044	Incr. 944	9,020	31.11	14.50	1.2	125
Y904	Incr. Y804	8,600	30.23	14.23	7.8	125
F69-13(413)	Incr 5 YRS US75	8,570	30.32	14.14	1.6	129
Y004	Incr. 904A	8,440	29.82	14.16	3.8	124
014	Incr 814, Imp. Val. Sel.	8,400	29.70	14.14	3.4	131
Y004B	Incr. 904B	8,240	28.39	14.52	1.1	126
813(Ore)	Incr 8YRS, 2 SS US75	8,170	27.98	14.62	0.2	128
Y022	Incr. 9111	7,860	27.45	14.32	0.9	129
868	Incr. US 75	7,810	27.15	14.38	0.3	130
Mean		8,580	29.72	14.44	2.4	Beets
LSD (0.05)		401	1.39	0.39	2.1	per
Coefficient of Variation - %		5.27	5.27	3.07	100.54	100'
F value		14.28**	10.93**	3.09**	9.30**	row

\*\* Exceeds the 1% point of significance (F=2.44)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1971  
Test 10

(10 replications each variety)  
(Two row plots)

Planted: September 15, 1970  
Harvested: June 7-8, 1971

Variety	Description	Acre Yield				Harvest Count
		Sugar Pounds	Roots Tons	Sucrose Percent	Bolting Percent	
044H46	(716H29 x 718) x 944	13830	42.53	16.28	2.6	128
Y004H46	(716H29 x 718) x Y904A	13710	42.74	16.05	6.0	126
USH10B	546H3 x C813	13560	39.44	17.22	2.1	132
USH9A	569H3 x 413	13490	40.21	16.80	1.2	129
Y904H45	(705H25 x 718) x Y804	13480	41.62	16.22	9.1	130
813H40A	(754H0 x 760) x F66-13	13330	40.79	16.40	10.5	129
813TH40(mix)	760H29 x 713T	13260	41.70	15.90	8.7	121
813H32A	(754H0 x 716) x 413	13230	41.11	16.08	5.5	124
USH10A	569H3 x C813	13120	38.59	17.02	1.6	129
USH9B	546H3 x 413	13080	39.17	16.70	1.2	125
813TH32(mix)	(754H0 x 716)x713T	13050	41.50	15.72	4.1	125
USH7A	546H3 x 664	12520	36.56	17.13	1.4	129
Mean		13300	40.50	16.46	4.5	127
LSD (0.05)		632	2.22	0.47	2.2	Beets per
Coefficient of Variation - %		5.36	6.17	3.21	55.13	100'
F value		2.39*	5.16**	9.06**	18.84**	row

\* Exceeds the 5% point of significance (F=1.89)

\*\* Exceeds the 1% point of significance (F=2.44)

VARIETY TEST, BRAWLEY, CALIFORNIA, 1971

Test 11

(10 replications each variety)  
(Two-row plots)

Planted: September 17, 1970  
Harvested: July 22-23, 1971

Variety	Description	Acre Yield		Sucrose Percent	Bolting Percent	Root Rot Percent	Harvest Count Number
		Sugar Pounds	Beets Tons				
Y904H45	718H31 x Y804	15,350	50.75	15.1	10.1	1.2	128
US H10B	546H3 x 813	15,320	50.09	15.3	2.0	0.4	136
US H10A	569H3 x 813	15,130	48.76	15.5	1.9	0.8	130
US H9A	569H3 x 413	15,010	49.25	15.2	1.8	0.2	132
Y004H46	(716H29 x 718) x Y904A	15,000	50.55	14.8	7.5	1.2	126
US H9B	546H3 x 413	14,900	48.48	15.4	2.8	0.7	132
044H46	(716H29 x 718) x 944	14,850	50.14	14.8	3.6	0.7	127
813TH40 (mix)	760H29 x 713T	14,680	49.25	14.9	8.8	0.7	126
813TH32 (mix)	716H29 x 713T	14,360	49.75	14.4	5.6	0.9	124
US H7A	546H3 x 664	14,000	45.99	15.2	0.3	0.3	136

Mean	14,860	49.30	15.1	4.5
LSD (.05)	337	1.80	0.34	2.1
Coefficient of Variation	4.24	4.09	2.55	52.59
F value	4.44**	4.69**	7.23**	19.05**

Beets  
per  
100'  
row

\*\*Exceeds the 1% point of significance (F=2.69)

## VARIETY TEST, IMPERIAL VALLEY, CALIFORNIA, 1971

Location: Calipatria, California

Holly Sugar Corporation

Variety	Extractable	Extractable	Gross	Beets /	Beets /	
	Sugar/Acre	Sugar/Ton	Sugar/Acre	Acre	100 ft.	Bolters
	Pounds	Pounds	Pounds	Tons	Number	Percent
<u>First date of harvest</u>						
US H9B	5,365	209.5	7,454	25.7	14.53	0.2
US H10B	5,323	211.3	7,359	25.2	14.61	0.1
US H10A	5,189	211.9	7,167	24.5	14.63	0.2
US H9A	5,116	209.8	7,101	24.4	14.55	0.9
C.V.	11	4.8	11	10.9	2.71	
LSD	399	6.6	533	1.8	.26	
<u>Second date of harvest</u>						
US H9B	8,715	277.7	10,684	31.3	17.03	3.8
US H10B	8,578	274.5	10,574	31.2	16.92	2.7
US H10A	8,506	270.5	10,560	31.4	16.79	1.4
US H9A	8,329	271.0	10,318	30.7	16.81	4.7
C.V.	12	5.7	11	10.8	3.14	
LSD	708	NS	799	2.3	.35	

Data extracted from tests consisting of 16 entries each.

VARIETY TEST, SAN JOAQUIN VALLEY, CALIFORNIA, 1971

Variety	Description	Extractable Sugar/Acre				Gross Sugar/Acre				Holly Sugar Corporation			
		Pounds	Pounds	Sugar/Ton	Pounds	Pounds	Acre	Tons	Beets / 100 ft.	Sucrose Percent	Percent	Number	
<u>Lindsay, California test</u>													
US H10B	546H3 x 813	4,211	209.2		5,863	20.3		14.51		191			
US H10A	569H3 x 813	4,193	220.1		5,735	19.4		14.93		191			
US H9A	569H3 x 413	4,086	219.3		5,592	19.0		14.89		185			
US H9B	546H3 x 413	3,931	218.5		5,414	18.5		14.84		188			
C.V.		12	7.9			11	12.1		4.46				
LSD		317	11.3		421	1.6		.43					
Data extracted from test of 16 entries.													
<u>Tracy, California test</u>													
F69-613H4	569H3 x 613	4,052	149.5		6,034	27.0		11.14		161			
US H9A	569H3 x 413	4,580	172.0		6,485	27.1		12.10		164			
US H9B	546H3 x 413	4,062	153.8		5,997	26.4		11.35		184			
C.V.		16	10.0			14	13.2		6.11				
LSD		753	18.2		968	3.9		.81					

Data extracted from test of 24 entries. Test inoculated with virus yellows 7-1-71.

DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR - 1971

GENERAL MEAN	SE of Mean	% of Mean
LSD @ P = .05		
LSD @ P = .01		

### # of Varieties in Test

### Planting Dates

January 23, 1971

January 27, 1971

January 29, 1971

## Harvest Dates

September 23, 1971

September 21, 1971

## DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR - 1971

Variety	Description	King City, California			Gonzales, California		
		Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H9A	569H3 x C413	3.892	28.58	13.4	5.364	37.68	14.3
US H9B	546H3 x C413	3.721	30.04	12.5	5.106	35.88	14.3
GENERAL MEAN		3.986	30.38	13.1	5.128	35.43	14.5
LSD @ P = .05		NS	NS	NS	0.482	2.29	0.7
LSD @ P = .01		NS	NS	NS	0.643	3.05	NS
SE of Mean	0.325	2.123	0.484	0.170	1.608	0.264	
SE in % of Mean	8.15	6.99	3.69	3.32	4.54	1.82	

# of Varieties in Test 8

Planting Dates January 28, 1971  
Harvest Dates October 30, 1971

February 2, 1971

October 18, 1971

## DATA ON USDA VARIETIES TESTED BY SPRECKELS SUGAR - 1971

Variety	Test Areas:			Coalinga, California			Mendota, California			Mendota, California		
	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar	Sugar T/Ac.	Beets T/Ac.	% Sugar
US H9A	569H3 x C413	2.644	20.58	12.8	3.583	27.88	12.9	3.592	24.54	14.7		
US H9B	546H3 x C413	2.760	21.59	12.8	3.918	30.91	12.7	3.991	27.27	14.4		
US H10A	569H3 x F70-17	2.903	22.39	12.9	3.526	27.37	12.9	4.046	27.89	14.6		
US H10B	546H3 x F70-17				3.949	30.73	12.8	4.065	29.96	13.6		
Y001H16	546H5 x Y801					3.651	25.39	14.4				
Y001H58	(7718H32 x 7714) x Y801					3.714	26.53	14.0				
Y004H16	546H5 x Y904A					3.543	25.23	14.2				
Y004H16B	546H5 x Y904B					3.954	27.74	14.3				
Y004H46	7718H32 x Y904A					3.727	28.33	13.1				
GENERAL MEAN	2.560	20.13	12.7	3.688	29.34	12.6	3.803	26.92	14.2			
LSD @ P = .05	0.373	2.62	0.5	0.414	3.23	NS	0.593	4.31	0.7			
LSD @ P = .01	0.498	3.49	0.6	0.549	4.29	0.7	0.785	5.71	0.9			
SE of Mean	0.131	0.920	0.162	0.147	1.148	0.190	0.211	1.536	0.252			
SE in % of Mean	5.12	4.57	1.28	3.98	3.91	1.51	5.54	5.70	1.77			
# of Varieties in Test	8			12			16					
Planting Dates	October 29, 1970			8			February 3, 1971			March 5, 1971		
Harvest Dates	August 10, 1971						September 23, 1971			September 20, 1971		

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beets /A	% Sugar	Impurity Index
(562 HO x 546) x C-413 (US H9B)	4357	3615	20.05	10.83	1153
(562 HO x 569) x Y 801	4735	3882	20.37	11.60	1207
(718 H32 x 714) x Y 801	4948	4074	21.29	11.62	1177
(563 HO x 546) x Y 904 A	5441	4627	22.14	12.32	998
(716 H29 x 718) x Y 904 A	5219	4324	22.56	11.57	1145
(563 HO x 546) x Y 904 B	4963	4118	22.00	11.27	1136
(563 HO x 546) x 944	4734	3909	21.52	10.93	1177
(705 H25 x 718) x Y 804	4834	4019	21.44	11.25	1134
SL 133 x 6-413	4744	4001	20.01	11.90	1056
68313 m x C-413	5254	4443	22.71	11.55	1030
68314 m x C-413	5054	4099	23.76	10.63	1256
546 HO x C-813 T	4576	3749	20.77	10.98	1220
546 HO x 55-205-0	3932	3247	17.77	11.02	1188
562 HO x 55-205-0	3849	3114	17.56	10.90	1287
68-313 ms x C-813 T	5056	4246	22.54	11.33	1116
68-315 ms x C-813 T	5283	4416	23.45	11.20	1103
68-316 ms x C-813 T	5080	4152	24.15	10.55	1225
SL (129 x 133) ms x C-813 T	4503	3723	19.95	11.32	1168
Overall Mean	4811	3987	21.34	11.26	1154
LSD (.05)	700	631	2.62	.74	156
F. Value	3.14	3.08	3.92	2.90	1.85
C. V. %	12.67	13.78	10.69	5.72	11.77

\* - Known Sugar Loss

Source	D/F	Gross Sugar	Gross Sugar	Tons Beets/A	% Sugar	Impurity Index
Replications	5	1,628,018	1,354,341	19.4551	3.3324	115,117
Varieties	17	1,167,497	931,532	20.4106	1.2035	34,179
Error	85	371,983	301,955	5.2010	.4156	18,446
Total	107					

Design: Randomized Block, 18 entries, 6 replications.  
 Plot Size: 2 row plots, 70 feet long, 30 inch rows.  
 Planted: February 18, 1971  
 Harvested: August 20, 1971

INTERSPECIFIC HYBRIDIZATION

VULGARIS-PROCUMBENS HYBRIDS

Helen Savitsky

Experiments were conducted with previously selected nematode resistant trisomics and diploid hybrids to study resistance transmission and to obtain new resistant hybrids. B<sub>2</sub> and B<sub>3</sub> resistant trisomics and diploid hybrids were kept in separate groups for interpollination within each group. Some susceptible diploid plants were added to provide sufficient viable pollen. The fertility varied in different plants, but seeds were harvested from nearly all plants. Insufficient fertility was caused in part by the environment. Seeds were set on some branches, whereas on the other branches of the same plant the flowers remained sterile.

To start the development of nematode resistant lines, B<sub>3</sub> progenies consisting of 4 to 10 nematode resistant plants were placed in isolated groups for seed production. The seed obtained from the interpollination of these closely related plants could be expected to have the same or similar chromosomal aberrations. Hybrids were tested for nematode resistance by planting seedlings in nematode infested soil as is described in previous reports. All plants were selected after three tests.

Results: Transmission of resistance from trisomic plants was studied in the progenies of four B<sub>1</sub> and four B<sub>2</sub> trisomic hybrids. In this experiment 1,170 plants were tested for resistance and 171 (14.61%) B<sub>2</sub> and B<sub>3</sub> resistant hybrids were selected. The group of resistant plants consisted of 112 (9.57%) new trisomics and 57 (5.04%) diploid hybrids. The frequency of resistance transmission varied considerably in different progenies (table 1). More resistant trisomics than resistant diploid hybrids were selected in the progenies of trisomics. Apparently, the univalent B. procumbens chromosome is transmitted more frequently to the poles and to gametes than crossing-over occurs. In this way, the nematode resistant trisomics provide a source from which new resistant trisomics and diploid hybrids may be obtained.

Transmission of resistance from diploid hybrids to the following generation was observed in the first progenies obtained last year, but there were too few progenies to study the frequency of transmission. Seed harvested from a larger number of diploid hybrids in 1970 permitted additional progenies to be tested in 1971. The progenies of 21 diploid resistant hybrids and the progenies of 12 resistant trisomics were tested for resistance (table 2). A total of 2,449 plants were tested and 256 (10.45%) resistant hybrids selected. Because a larger number of plants were tested in the progenies from diploid hybrids, more resistant plants were selected from diploid hybrids (225 plants) than from trisomics (31 plants). Frequency of resistance transmission from trisomics (11.65%) and from diploid hybrids (10.31%) were similar in this experiment.

The first resistant diploid hybrid population derived from trisomics after crossing-over or translocation between B. vulgaris and B. procumbens chromosomes will include different chromosomal aberrants. The majority of diploid resistant plants will have a segment of B. procumbens chromosomes attached or incorporated into the chromosome of B. vulgaris. The length of the acquired B. procumbens segment will vary in different plants depending on the place in the chromosome where the crossing-over occurred. The length of the B. procumbens segment will influence pairing and crossing-over with the homologous chromosome of B. vulgaris and also the frequency of transmission of the cross-over chromosome to the gametes. If translocation took place, the segment of B. procumbens chromosome may be attached to different B. vulgaris chromosomes (to different linkage groups). Some resistant hybrids may be monosomics and have the complete B. procumbens chromosome and 17 chromosomes of B. vulgaris.

Because of different genetic structures, the individual resistant diploid plants will differ in their ability to transfer resistance to the following generation. Data obtained characterize the first diploid populations in general. However, when even one highly resistant line is developed, the frequency of resistance transmission will change drastically. The resistant diploid hybrids represent basic material to which resistance has already been transmitted, but further investigation and breeding should be continued with these hybrids. Propagation and hybridization of resistant plants may induce additional crossing-overs and improve the ability of the cross-over chromosome to pair with the homologous chromosome of B. vulgaris which will increase the frequency of resistance transmission. The selection of plants with an increased frequency of transmission followed by a cytological study is necessary if we are to develop a highly resistant line or lines with a high frequency of resistance transmissions.

Table 1. Transmission of nematode resistance from trisomic hybrids.

Plant No.	Plants tested	Resistant hybrids selected					
		19 chromosomes		18 chromosomes		Total	
	Number	Number	Percent	Number	Percent	Number	Percent
<u>B1</u>							
		<u>B2 plants</u>					
3742	393	39	9.92	26	6.62	65	16.54
4651	199	24	12.06	10	5.03	34	17.09
4264	142	4	2.82	10	7.04	14	9.86
4678	73	4	5.48	1	1.37	5	6.85
<u>B2</u>							
		<u>B3 plants</u>					
9-1	97	9	9.28	1	1.03	10	10.31
9-6	91	15	16.47	5	5.49	20	21.98
6810	81	9	11.11	5	6.17	14	17.28
6978	94	8	8.51	1	1.06	9	9.57
	1,170	112	9.57	59	5.04	171	14.61

Table 2. Transmission of nematode resistance from trisomics and diploid hybrids.

TRISOMICS				DIPLOID HYBRIDS			
Progenies tested	Plants tested	Resistant selections		Progenies tested	Plants tested	Resistant selections	
Number	Number	Number	Percent	Number	Number	Number	Percent
12	266	31	11.65	21	2,183	225	10.31
Total plants tested	-	2,449					
Total plants selected	-	256					
Percent selected	-	10.45					

### VULGARES-COROLLINAE HYBRIDS

Helen Savitsky and J. S. McFarlane

Vulgaris-corioliflora hybrids. Seed harvested from B<sub>3</sub> curly top resistant hybrids were planted and 576 B<sub>4</sub> young plants were tested for curly top resistance. Plants were inoculated with a highly virulent strain of curly top virus isolate 66-10. Inoculation of plants and selection for resistance was done by Dr. McFarlane. In this hybrid population, 175 plants showed only mild curly top symptoms and 24 plants showed no symptoms of disease after two inoculations. They were apparently immune or highly resistant.

After thermal induction, plants selected were transplanted for seed production. The group of highly resistant hybrids was isolated from the group which showed mild symptoms. Pollen development and fertility were better in the B<sub>4</sub> than in the B<sub>3</sub> generation. Seed was harvested from both groups of hybrids. Chromosome numbers were determined in the highly resistant hybrids. They all had 19 chromosomes with exception of two plants which had 20 chromosomes. Presence of curly top resistant trisomics indicate that apparently one chromosome and one major gene in B. corolliflora is responsible for the high level of curly top resistance.

Vulgaris-macrorhiza hybrids. New interspecific hybrids were obtained between tetraploid sugarbeet and diploid B. macrorhiza. The ten F<sub>1</sub> plants were triploid (27 chromosomes). The F<sub>1</sub> hybrid plants were vigorous with large roots and large leaves. Flowers, anthers, and seedballs were also large. All hybrids were extremely male-sterile with large, long anthers that were completely empty of pollen. Female fertility was very high and nearly all seedballs contained germs. Seed germination was good.

The B<sub>1</sub> hybrids were planted for the first time in 1971 and the young plants were tested for curly top resistance. They were inoculated with virus isolate 66-10. The inoculation and selection for curly top resistance was done by Dr. McFarlane. The B<sub>1</sub> hybrid population showed a high level of curly top resistance. Of 127 plants tested, 85 showed no disease symptoms.

The B<sub>1</sub> hybrid seedlings were very vigorous with long, broad cotyledons which were much larger than those of the cultivated sugarbeet. Vigor and other plant characteristics were determined by transplanting 103 hybrid seedlings in a greenhouse bed and allowing them to grow for several months. Seedlings of sugarbeet were also transplanted in the bed. The hybrids showed much greater plant vigor than did sugarbeet. The average weight per plant for both leaves and roots was approximately two times higher in the hybrids compared with sugarbeet (table 3). These are preliminary data which need to be verified in the field.

The excellent vigor and curly top resistance of the vulgaris-macrorhiza hybrids are valuable characters. The sugarbeet originated from hybridization of Swiss Chard with fodder beets. Probably new types of sugarbeet with greater vigor can be developed through hybridization with B. macrorhiza. Further experiments will indicate whether heterosis as exhibited by the macrorhiza hybrids can be utilized in sugarbeet breeding.

Table 3. Comparison of leaf and root weights of vulgaris-macrorhiza hybrids with those of sugarbeet.

Kind of Beets	Plants	Total Weight		Weight of Leaves per Plant	Total Weight	Weight of Roots per Plant
		Number	Grams		Grams	Grams
Sugarbeet	21	600		28.57	1,300	61.90
B <sub>1</sub> hybrids	103	5,700		55.33	11,900	115.53

Weight difference in favor  
of macrorhiza hybrids:

Leaves - 26.76 grams

Roots - 53.63 grams



Photo 1. Vulgaris x procumbens nematode resistant diploid hybrids.



Photo 2. Vulgaris x corolliflora curly top resistant trisomic hybrids.



Photo 3. Vulgaris x macrorhiza curly top resistant B<sub>1</sub> hybrids.

Nematode Resistance of the B<sub>3</sub> Generation of  
B. vulgaris x B. procumbens Hybrids

James C. Read

Seeds from B<sub>2</sub> vulgaris-procumbens hybrids were obtained from Dr. H. Savitsky. The B<sub>2</sub> plants were trisomic and were resistant to the sugarbeet nematode (Heterodera schachtii). The extra chromosomes were derived from B. procumbens and carried the gene or genes for resistance.

A total of 1,174 B<sub>3</sub> plants have been obtained. Testing has been completed on 180 of these plants and 15 were resistant to the sugarbeet nematode.

The cytology on the resistant plants is being conducted to determine if the gene or genes for resistance has been transferred to the sugarbeet chromosome. Additional plants are being obtained and tested as time and facilities dictate.

## VIRUS INVESTIGATIONS

Relationships of the aphid transmitted yellowing viruses of plants

James E. Duffus

The importance and widespread distribution of beet western yellows virus is becoming more evident each year. The virus has been reported from North America, Europe and Asia, and is probably common throughout the world. The virus causes stunting and chlorosis of a wide range of dicotyledonous species, including sugarbeet, red beet, spinach, lettuce, broccoli, cauliflower, radish, turnip, pea, and flax.

The interrelationships of beet western yellows virus and yellowing viruses reported on sugarbeets and other crops from various parts of the world are significant from the standpoint of breeding for resistance and disease epidemiology.

Turnip yellows virus described by Vanderwalle in 1950 from Belgium was known for some years previous to this in Europe. The virus induces a red discoloration along the edges of infected turnip leaves, followed by an intense chlorosis of the whole blade, which becomes hard and brittle. Diseased plants remain dwarfed and have small roots. The disease has been shown to be widespread in Europe, occurring in Belgium, Germany, England and Denmark.

The virus, transmitted in a persistent manner by Myzus persicae seems to have a host range mostly in the Cruciferae.

Observations in England, Scotland, Denmark and Germany suggested that beet western yellows virus (BWYV) was present in weed and crop hosts in these areas. Subsequent serological studies proved the presence of BWYV in Europe.

The occurrence of BWYV in Europe, the similarity of symptom expression on key indicator hosts, and the similarity in transmission characteristics indicated a possible relationship between BWYV and turnip yellows virus. Studies in cooperation with Dr. G. E. Russell were then initiated to determine the relationships between isolates of BWYV from California and England to isolates of turnip yellows virus from England and Germany.

The handling of aphids, strains of BWYV, membrane feeding technique and antigen and antiserum preparation were as reported in previous publications (Duffus, 1965, 1967).

Results.--Host range. Previous host range tests with isolates of turnip yellows virus have indicated an extremely narrow host range for these isolates; mostly in the Cruciferae. In most instances plants that were tested and gave negative results were not reported, and it has been difficult to compare isolates of this virus with isolates of BWYV in regard to host range. For this reason one isolate (from England) was selected for extensive studies.

Some 25 species of plants in nine families were shown to be susceptible to infection and 22 species immune or highly resistant.

The English isolate of turnip yellows virus studied in these tests produced a reaction on certain key indicator hosts very similar to that reported for English isolates of BWYV. Beta vulgaris (sugar-beet), R. sativus, B. pekinensis, C. capitatum, and S. oleraceus were immune to this isolate. Brassica rapa, L. sativa, C. bursa-pastoris, N. clevelandii, S. vulgaris and Claytonia perfoliata were all susceptible. Most species produced good diagnostic symptoms when infected. S. vulgaris, C. perfoliata and L. sativa, species commonly used in BWYV indexing tests, showed, however, very mild symptoms after a long incubation period. Beta macrocarpa and Nicandra physalodes, unlike the English isolates of BWYV, were apparently immune to this isolate of turnip yellows virus.

Membrane feeding.--The application of a membrane feeding technique to turnip yellows virus was necessary to facilitate further characterization of the virus through serological testing by infectivity neutralization. The similarity of symptoms and vector relationships of BWYV and TuYV led to membrane feeding studies using techniques shown to be successful for BWYV. It was found that the isolates of TuYV could be successfully transmitted to healthy C. bursa-pastoris seedlings by green peach aphids feeding through Parafilm (Marathon Products, Neenah, Wisconsin) membranes on density-gradient fractions of crude and concd. sap from infected C. bursa-pastoris. The infectious fractions in the density-gradient columns appeared to be in one zone 18-26 mm from the top of SW-39 tubes. This is the same location in the density-gradient columns from which BWYV has been repeatedly recovered.

Serological relationships.--The demonstration by Gold and Duffus that infectivity neutralization could be utilized to determine a serological reaction by feeding aphids through membranes on virus-antisera reactants prompted an attempt to study the serological relationship of BWYV and the TuYV isolate from Europe. Since previous work with green peach aphids had indicated poor feeding when the insects were fed directly on the virus-antisera reactants, the reactants were subjected to density-gradient centrifugation prior to the feeding of the insects. In this case evidence of serological reaction was based on the failure to encounter infectivity in the normal virus zone.

Nine antisera prepared from eight different strains of BWYV from America and England and Beet Yellows virus (BYV) from America were tested against the English isolate of TuYV (Table 1). Antisera prepared against the English isolate of TuYV and an English isolate of BWYV were tested against nine BWYV strains from America and England and the TuYV isolates from England and Germany (Table 2).

Antiserum against healthy shepherds purse, saline or antiserum against the beet yellows virus did not affect infectivity of TuYV. Antisera against all the BWYV strains tested effectively neutralized the infectivity of TuYV.

Antiserum against the English isolate of TuYV completely neutralized all infectivity of the BWYV strains tested and the TuYV isolates from England and Germany.

DISCUSSION.--The results of these experiments establish a close serological relationship between BWYV from America and England and TuYV from turnips in England and Germany. Further, they establish a relationship between turnip yellows virus (turnip mild yellowing virus) from England and from Germany.

The results indicate that TuYV isolates from Europe have a wider host range than was previously recognized; a host range which may affect crop plants in families other than the Cruciferae.

The relationship of TuYV isolates and other BWYV variants to yellowing diseases of flax, pea, broadbean and turnip, reported from other parts of the world have not as yet been studied. The possibility exists that BWYV is also involved in several of the yellowing diseases. Evidence is accumulating which indicates that BWYV is extremely widespread in the world, occurring naturally on a large number of wild and cultivated crops, and occurring in a number of strains or variants with distinctive host ranges.

Little information is available on the economic significance of BWYV isolates except those occurring on sugarbeet and lettuce. The damage induced by TuYV isolates on turnip in Europe is however well documented. But, the effects of these isolates on other Cruciferous crops has been given little attention. In the coastal areas of California, Cruciferous crops (broccoli, cauliflower, cabbage, and mustards) have a very high incidence of BWYV, but little is known of the effects of the virus in regard to yield or uniformity on these crops.

Table 1. Serological interactions of BWYV antiserum with English turnip yellows virus (TuYV).

Sample tested	Infectivity of virus zone after incubation with the indicated sera
ASHSP <sup>a</sup> + TuYV <sup>b</sup>	110 <sup>c</sup> 120
Saline + TuYV	113 120
ASBYV + TuYV	37 40
ASST1-1 + TuYV	0 40
ASST3-1 + TuYV	0 80
ASST7-2 + TuYV	0 40
ASST7-3 + TuYV	0 40
ASST8-1 + TuYV	2 40
ASST9-1 + TuYV	0 40
ASST11-1 + TuYV	1 40
ASE1-1 + TuYV	0 40
ASE3-1 + TuYV	0 40

<sup>a</sup> Antiserum to healthy shepherd's purse (ASHSP); antiserum to beet yellows virus (ASBYV); antiserum to strain 1 BWYV (ASST1-1); antiserum to strain 3 BWYV (ASST3-1); etc.

<sup>b</sup> The virus samples were obtained from infected shepherd's purse, cleared by low-speed centrifugation, and pelleted by ultracentrifugation. Pellets were resuspended in buffer to approximately 1/50 of the original volume of sap. The virus sample was mixed with an equal volume of serum and incubated for 2 hr at 37 C. Incubated mixtures were subjected to density-gradient centrifugation, and samples for infectivity assays were removed from the zone 18-26 mm from the top of SW 39 tubes.

<sup>c</sup> The numerator indicates the number of plants infected and the denominator the number of plants inoculated by 10 green peach aphids fed through membranes on each sample.

Table 2. Serological interactions of turnip yellows virus antiserum (ASTuYV) with BWYV isolates.

Sample tested	Infectivity of virus zone after incubation with the indicated sera										
	TuYV-E <sup>a</sup>	TuYV-G	ST-1	ST-2	ST-3	ST-7	ST-8	ST-10	ST-11	E-1	E-3
ASHSP <sup>b</sup> + virus <sup>c</sup>	$\frac{39}{40}^d$	$\frac{38}{40}$	$\frac{37}{40}$	$\frac{18}{20}$	$\frac{18}{40}$	$\frac{40}{20}$	$\frac{19}{20}$	$\frac{18}{20}$	$\frac{37}{40}$	$\frac{36}{40}$	$\frac{40}{40}$
ASEI + virus	$\frac{0}{40}$	$\frac{0}{40}$	$\frac{1}{40}$	$\frac{0}{20}$	$\frac{0}{20}$	$\frac{1}{40}$	$\frac{0}{20}$	$\frac{0}{20}$	$\frac{0}{40}$	$\frac{0}{40}$	$\frac{0}{40}$
ASTuMV + virus	$\frac{0}{40}$	$\frac{0}{40}$	$\frac{0}{40}$	$\frac{0}{20}$	$\frac{0}{20}$	$\frac{0}{40}$	$\frac{0}{20}$	$\frac{0}{20}$	$\frac{0}{40}$	$\frac{0}{40}$	$\frac{0}{40}$

a TuYV-E (turnip yellows virus-England); TuYV-G (turnip yellows virus-Germany); ST-1, ST-2, ST-3, ST-7, ST-8, ST-10, ST-11 (American strains of BWYV; E-1, E-3 (English strains of BWYV).

b Antiserum to healthy shepherd's purse (ASHSP); antiserum to English isolate 1 BWYV (ASEI); antiserum to English isolate TuYV (ASTuYV).

c The virus samples were obtained from infected shepherd's purse, cleared by low-speed centrifugation, and pelleted by ultracentrifugation. Pellets were resuspended in buffer to approximately 1/50 of the original volume of sap. The virus sample was mixed with an equal volume of serum and incubated for 2 hr at 37°C. Incubated mixtures were subjected to density-gradient centrifugation, and samples for infectivity assays were removed from the zone 18-26 mm from the top of SW 39 tubes.

d The numerator indicates the number of plants infected and the denominator the number of plants inoculated by 10 green peach aphids fed through a membrane on each sample.

## ULTRASTRUCTURAL STUDIES

Lynn L. Hoefert

### Beet Yellows Virus

Research on beet yellows virus with the electron microscope has been directed toward a comparison of effects of the virus on different hosts. Effects of the virus are similar in many respects on both sugarbeet (1,2,3) and Tetragonia (4,5,6,7). In Tetragonia, leaves of different ages were examined to study the progress of the disease in the plant. The vascular tissue contained large amounts of virus in leaves older than the second or third leaf. The first virus particles were seen in sieve elements and in phloem parenchyma cells. In progressively older leaves, the virus accumulated in vascular cells to such an extent that little else was present in some (6;fig.1&2). Table I shows a comparison of relative amounts of virus seen in sections of leaves of different ages.

Characteristic banded and fibrous inclusion bodies, composed of virus particles, were found in leaf mesophyll and phloem cells (fig.1,2), and were essentially similar to those previously described in sugarbeet (1). Systemically infected plants were used for study; the first abnormalities associated with movement of BYV in the phloem to young tissues was the appearance of vesicles that contained networks of fine fibrils. Vesicle aggregates assumed such proportions that they were visible with the light microscope (5). Virus particles were found in the cytoplasm among the vesicle aggregates. Similar vesicles were found in sugarbeet cells infected with beet mosaic virus (8) and beet yellow stunt virus (9). It has been suggested that the vesicles contain viral RNA (the fine fibrils).

Virus particles accumulated in vascular parenchyma and especially in sieve elements of the older leaves (6). Fig. 3 shows a sieve plate joining two sieve elements; the upper one packed with virus particles. Phloem parenchyma and sieve elements showed degenerative changes in older leaves (6). In addition, a morphological change was observed in the virus particles themselves (7) leading to the conclusion that in older yellowed leaves, the virus particles degenerate. Virologists have encountered difficulties in transmitting virus from old yellow leaves and we regard the observed virus degeneration as an explanation of the transmission problem.

Ample evidence was obtained that beet yellows virus in Tetragonia, as in Beta, moves from cell to cell through plasmodesmata (figs.4-6).

Table I. Effects of beet yellows virus on leaves of different ages (Tetragonia expansa).

Leaf no.	Visual Symptoms	Rel. Amt. Virus*	Degenerated Virus	Tissue Assoc. of Virus
1	None	1	-	Sieve elements, phloem parenchyma
2	Sl. veincl.	3	-	" "
3	Veincl.	4	-	" "
4	"	4	-	" "
5	"	4	-	" "
6	"	5	-	" "
7	Veincl. & yel.	5	+	Vasc. tissue, mesophyll
8	Yel.	6	+	" "
9	Yellow.	8	+	" "
10	Yel. leathery	10	+	" "

\* A scale of 1-10 was selected; 10 would indicate ten times as much virus as 1. These values are approximate - based on observations with electron microscope.

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Fig. 1. Sieve element from leaf of BYV-infected Tetragonia.  
M, mitochondrion; P, sieve element plastid; sieve element filled with flexuous virus particles. X 15,000.

Fig. 2. Enlarged view of same sieve element showing individual virus particles packed in sieve element. X 31,000.

Fig. 3. Sieve plate between contiguous sieve elements showing BWY virus particles traversing pore; c, callose. X 60,000.

Fig. 4. Portion of side wall between two sieve elements showing partial view of plasmodesmatal pore lined with callose and filled with BWY virus particles. X 56,000.

Figs. 5 & 6. Incomplete sections of plasmodesmata between sieve elements and parenchyma cells showing virus particles in pores. Both X 70,000.

### Beet Western Yellows Virus

Electron microscopy of sugarbeet leaves infected with beet western yellows virus has revealed isometric particles 24-30 nm in diameter. Previous studies (1,2) suggested that beet western yellows virus was a small spherical particle but had not shown the virus in tissue sections.

Beet western yellows virus particles are slightly larger than host cell ribosomes, more dense in staining, and possess a sharper outline (figs.7,8;virus particles at arrows). Many particles show an electron lucent center (fig.8,9). In young leaves of systemically infected plants, the first particles were found in sieve elements (fig.9), sieve-plate pores, and traversing plasmodesmata between sieve elements and adjacent phloem parenchyma cells (fig.8). In older leaves, virus particles were more numerous in phloem parenchyma cells and sometimes were even found in mesophyll cells adjacent to the phloem. Particles were not found spatially isolated from the vascular tissue, that is, in mesophyll cells not in contact with the vascular parenchyma. Thus, we regard beet western yellows virus as one that is more closely restricted to the phloem than is beet yellows virus.

In a newly-infected cell, particles of beet western yellows virus first appear within the nucleus, at the periphery of the nucleolus. In this respect, the beet western yellows virus more closely resembles insect viruses than it does other plant viruses. Very few plant viruses have been found in nuclei and of those, most are persistent aphid-transmitted viruses like beet western yellows.

A consistent feature of early cytological effects of beet western yellows virus (as well as beet yellows virus) was the formation of vesicles containing fine fibrils (fig.10). Attempts are being made to characterize cytochemically the fine fibrils contained in the vesicles.

Observations of cells infected with beet western yellows virus have led to recognition of the virus particles, distinction of the particle from other cell components, and a potentially faster means of diagnosing beet western yellows virus than we have had to date.

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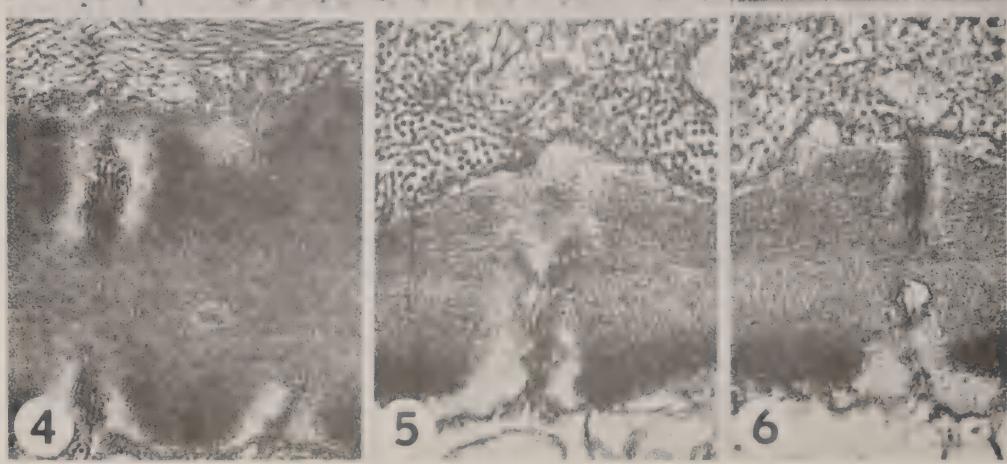
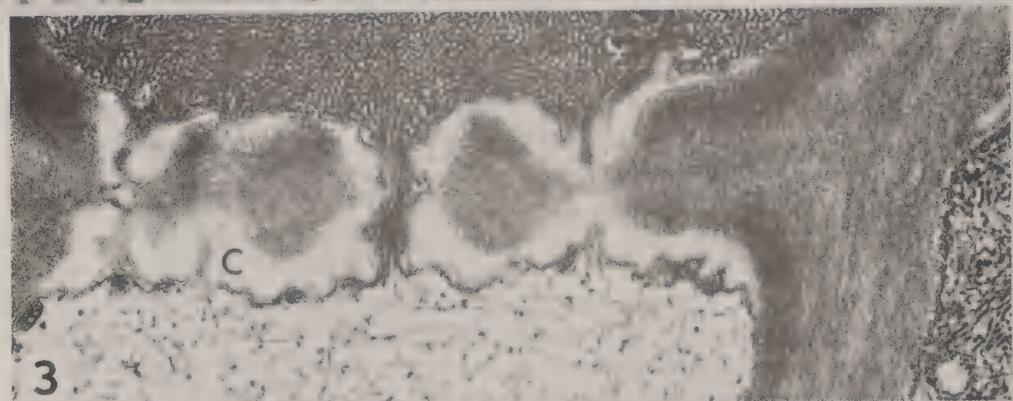
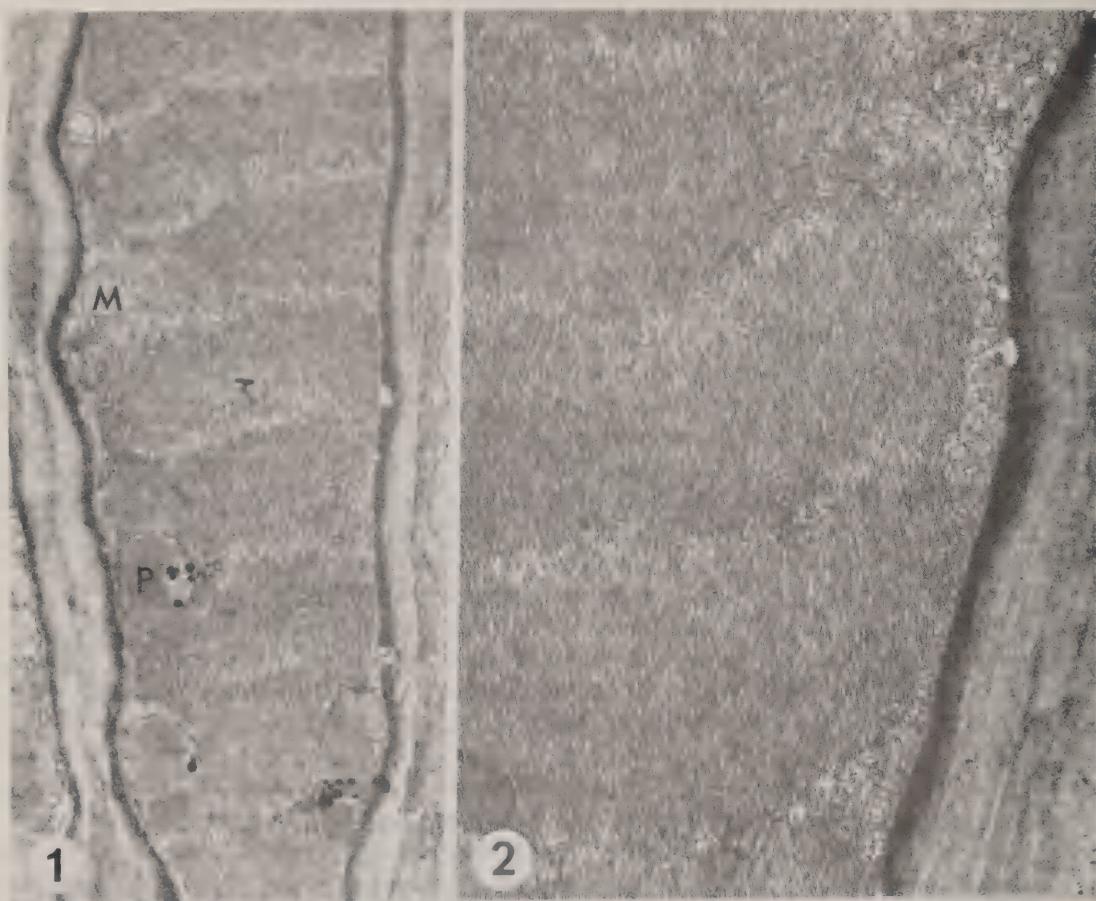


Fig. 7. Spherical BWYV particles in mature sieve element. X 60,000.

Fig. 8. Spherical virus particles in plasmodesma between sieve element (top) and adjacent parenchyma cell. X 60,000.

Fig. 9. Spherical particles in sieve element (se) appear dissimilar in size and density from ribosomes in adjacent parenchyma cell (pa). X 48,000.

Fig. 10. Vesicles with internal fibrils characteristic of early infection of cells with BWYV. X 60,000.

Fig. 11. Composite drawing of stages in pollen development in sugarbeet, from tetrad of microspores to mature pollen grain with sperm cells. Details in text.

Table II. Microspore stages relative to changes in tapetal cells of Beta.

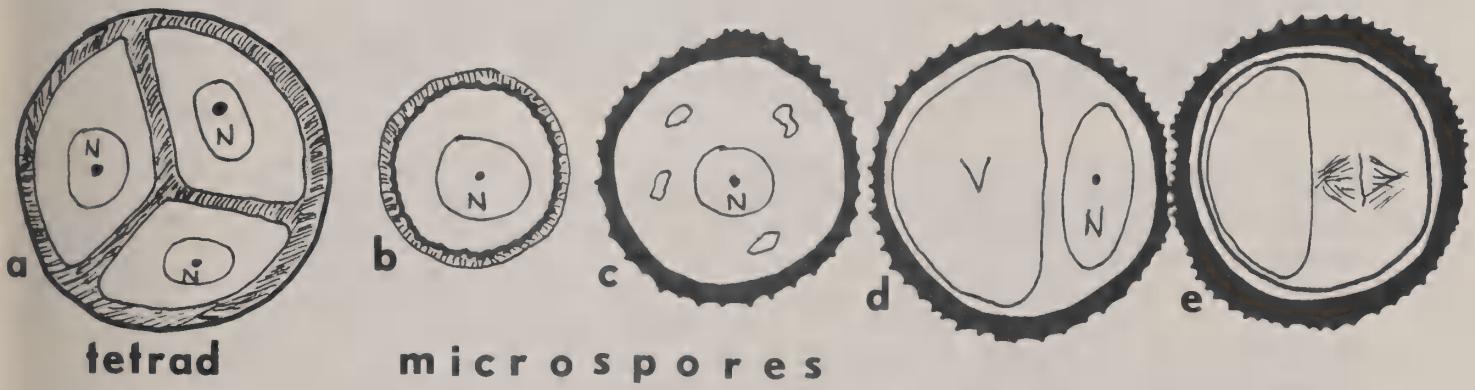
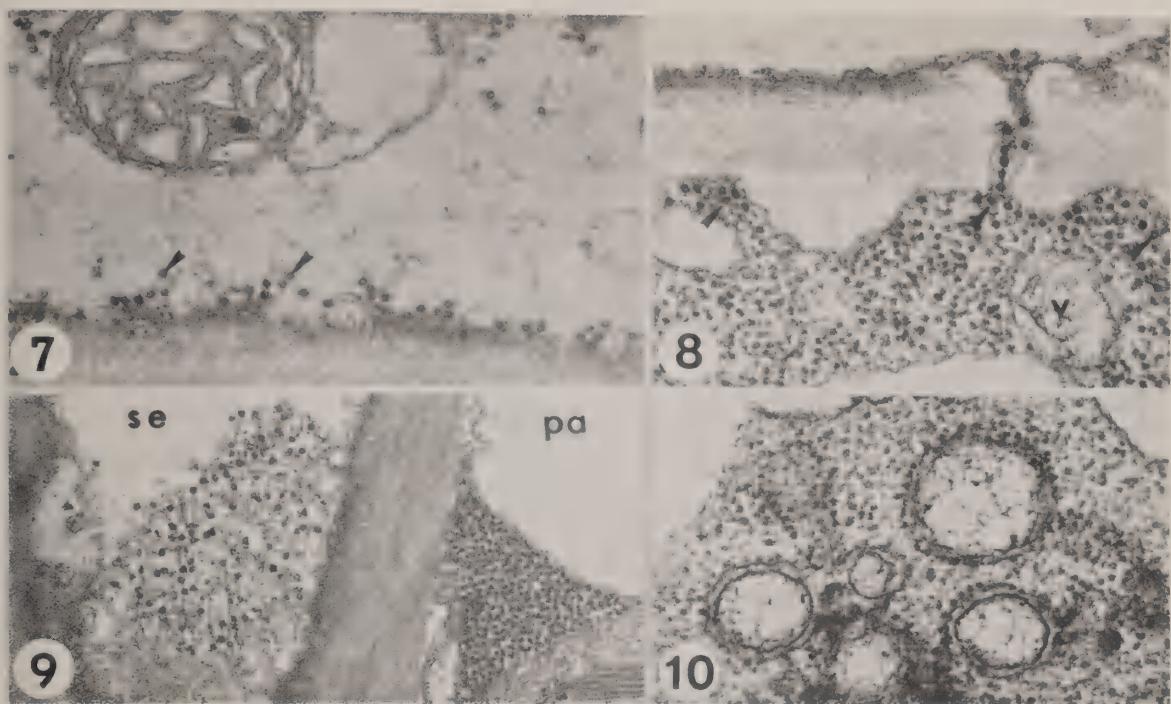
Microspore Stage	Changes in Tapetal Cells
Pre-Meiosis Pollen Mother Cells	Division to Binucleate Cell Maturation
Meiosis to Tetrad	Tapetal Walls Disappear
Released Microspores	Tapetal Walls Gone
Vacuolate Microspores	Plasma Membrane Ruptures Nuclear Membrane Ruptures Cytoplasm Released into Anther Locule
Microspore Mitosis	Tapetal Cell Cytoplasm Gone from Anther Locule

### Sugarbeet Pollen Development

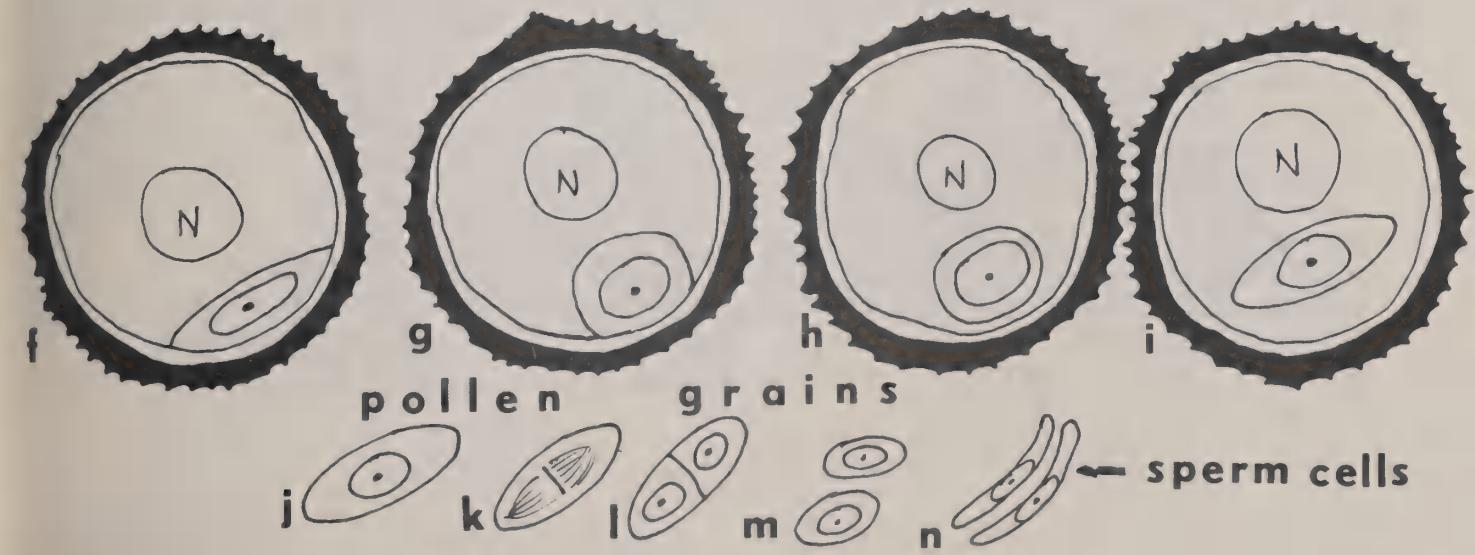
An outline of pollen development in sugarbeet anthers is represented diagrammatically in fig. 11. Diagram based upon abstract (Hoefert, 1971a). The products of meiosis, the microspores, are enclosed in a callose special wall, represented as a hatched wall (a). The callose dissolves and individual microspores are released into the anther locule. The pollen wall, or exine, begins to be deposited at this stage and the last remnants of callose wall disappear (b). Small vacuoles develop in the microspore cytoplasm (c); these coalesce to form the vacuolate microspore (d). At approximately the same time that the microspore nucleus divides by mitosis (e), the intine or inner pollen grain wall is being formed. This first mitotic division produces a pollen grain with a vegetative nucleus (N) and a generative cell, the wall of which is contiguous with the intine of the pollen grain (f). The generative cell wall is limited on either side by two membranes. The generative cell pushes into the pollen cytoplasm (g) and eventually becomes detached from the intine (h). The wall material between the generative cell limiting membranes disappears, and the generative cell assumes an elliptical shape prior to its division (i,j). The generative cell nucleus then undergoes mitosis (k) to form two sperm cells (l) which separate (m) and elongate into the two sperm cells (n) characteristic of the mature pollen grain of Beta.

As the events just outlined progress, certain changes take place in the tapetal cells that line the anther locule. Table II shows the microspore stages just described in relation to the changes in tapetal cells. Early in anther ontogeny, the tapetal cells differentiate from sporogenous cells to become dense, much like meristematic cells. The tapetal nuclei divide by mitosis to produce binucleate tapetal cells (cf. Hoefert, 1971b). Thereafter tapetal cells differentiate into characteristic secretory cells. Degenerative changes begin to occur in tapetal cells just after meiosis in the anther. Inner tapetal cell walls, and anticlinal walls, disappear; tapetal nuclei are disrupted, and changes occur in the tapetal cell organelles. Tapetal cell cytoplasm disappears completely by the stage of microspore mitosis.

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- (2) Hoefert, L. L. 1971b. Ultrastructure of tapetal cell ontogeny in Beta. Protoplasma 73:397-406.



## 11 BETA POLLEN DEVELOPMENT



Root Rot Evaluations, 1971

E. D. Whitney

Root and crown-rot of sugarbeet in California in recent years have attracted increased attention from growers and fieldmen, however, little research has been done to evaluate the cause of the rot or the value of root-rot resistant selections in reducing these rots.

Three tests were conducted in 1971 to aid in clarifying the rot problem: 1) Etiology of rots, 2) Crown-rot of Rhizoctonia solani root-rot resistant selections, and 3) Isolates x selections x technique effects.

Etiology of rots.--To determine if R. solani is the major pathogen inciting rot of sugarbeet, samples from central and southern California were evaluated. In cooperation with Spreckels Sugar Company and the Union Sugar Division, beet fields which showed rot were located during the months of July, August, and September. A sample, of about 10 beets, with early symptoms of rot was selected from each location. Thirty small pieces of root tissue from near the edge of the necrotic area were taken from each beet. Ten surface disinfested pieces from each beet were placed on three media; potato-dextrose agar, cornmeal agar, and a media selective for Rhizoctonia.

The results of these tests, Table 1, for 1971 do not support the common belief that R. solani is the major incitant of sugarbeet crown and root-rot in California. Of the areas selected only 16.1 percent showed the majority of the rotting beets infected with R. solani and only 38.7 percent had any beets infected with the fungus. The data suggest that the techniques used were effective in isolating the fungus because in several tests a majority of the beets had R. solani. Whether these data are representative of several years testing or peculiar to one year remain to be determined.

Crown-rot of R. solani root-rot resistant selections.--Isolations of R. solani from beets grown in a few selected areas of California in 1970 showed crown-rot isolates of sugarbeet to be more common than root-rot isolates. Because of this observation, resistant selections FC 701/2 and FC 702/2 and their respective parents were tested in 1971 for resistance to crown-rot. Four R. solani isolates, RB-6 from Fort Collins, Colorado (a root-rot isolate), Rs 5 and 11 from Visalia, and Rs 21 from King City, California (crown-rot isolates) were used to test for crown-rot resistance. The rosette method of applying the inoculum was used. Following the placement of the inoculum (barley-fungus) in the crown of the beet, each plant was sprinkled with water to wet the inoculum. The plants were then placed in a high humidity chamber (100 percent) for five days at  $27 \pm 5$  C. The plants were five months old at the time of inoculation. Two months later plants were harvested, weighed, split and rated for crown-rot on a scale of 0 to 4.

Zero represented healthy beets and 4, beets with nearly complete rot of the crown. The factorial experiment was arranged in a split plot design with inoculum treatments as whole plots and selections as sub-plots. The experiment was completely randomized with 6 plants per treatment. The test was repeated once.

The results of the two tests are shown in Table 2. The analysis showed a significant reduction in yield due to fungus isolates 11 and 5 and a reduction by isolate 21 at the 10 percent level when compared with the effects of isolate RB-6. The isolates times varieties interaction was not significant, therefore, all varieties reacted similarly to all isolates. There was no effect on crown-rot by RB-6 and root-rot was minor. All four varieties reacted similarly and were equally susceptible to the California crown-rot isolates, Table 2. The parent varieties were higher in yield than the selections but only GW 674-56C was significantly higher. This is in agreement with tests at Fort Collins. There was no difference between tests.

These data suggest that resistance to root-rot isolates of R. solani does not necessarily confer resistance to crown-rot isolates and that the two types of resistance are probably inherited independently. The data suggest that under the conditions of these tests, two months is insufficient time to cause serious root-rot and show differences between the resistant and susceptible lines.

Isolates x selections x inoculation techniques.--A test was performed to study the effects of four California crown-rot R. solani isolates and RB-6 isolate from Fort Collins on FC 701/2, FC 702/2, their respective parents, and FC 703, a cross between the two selections. Two inoculation techniques (rosette and placement of inoculum 1 inch deep and 1 inch from the tap root) were used. The experiment was carried out under field conditions with sugarbeets grown in 3 gallon crocks of soil. Each crock had two plants at the time of inoculation. A factorial design was used for the experiment. All treatments were completely randomized. Each treatment had 6 replications. Approximately 1/8 teaspoon of barley-fungus inoculum was used per plant. All plants were sprinkled every 2 hours during the day for 1 week. The plants were inoculated 2 months after planting and harvested 3 months later.

The analysis showed a significant difference between varieties and fungus isolates. The root-rot isolate RB-6 caused a significant reduction in yield but was most severe in the susceptible parents, Table 3. The crown-rot isolates caused no significant reduction in yield. There was a fungus times inoculation interaction resulting from greater losses in plant yield when the inoculum (RB-6) was placed in the soil. Selections FC 701/2 and FC 703 significantly out yielded the susceptible selections, however, FC 702/2 was not significantly different than the susceptible parent.

The resistant selection was observed to produce a smoother tap root with less scurf than the susceptible parent. This was true whether the plants were inoculated or grown in autoclaved soil, Fig. 1.

The data confirm the results of tests in Colorado and Michigan that selections resistant to R. solani root-rot isolates have been established. The data suggest that the resistance in FC 701/2 and FC 703 is superior to FC 702/2 under the conditions tested. The observation that resistance may be correlated with smoothness of root and freedom from scurf could be a criterion for removing susceptible segregates from the resistant lines.

The previous work supports the findings of this test and suggests that the technique used for determining root-rot resistance may not be adequate to select for crown-rot resistance. These studies indicate that some effort should be placed on the development of techniques to select for crown-rot resistance.

Table 1.

ISOLATIONS FOR 1971

Location and (Cooperator)

<u>Imperial Valley (Union Sugar Div.)</u>		
<u>No. Location</u>	<u>No. Beets</u>	<u>No. Beets with R. solani</u>
1	3	0
2	3	0
3	5	3
<u>Santa Maria (Union Sugar Div.)</u>		
1	3	0
<u>Blackwells Corner Area (Union Sugar Div.)</u>		
1	13	3
2	7	0
3	7	0
4	8	0
5	3	0
6	4	0
7	10	2
<u>San Joaquin Valley (Spreckels Sugar Co.)</u>		
1	10	1
2	10	0
3	10	8
4	10	6
5	10	4
6	10	0
7	7	0
8	10	0
9	10	2
10	10	7
11	8	0
12	10	0
13	6	0
14	10	0
15	10	8
16	7	0
17	4	4
18	6	0
19	7	1
<u>Woodland (Spreckels Sugar Co.)</u>		
1	10	0

Beets with some R. solani -- 12/31 -- 38.7%.

Majority of beets with R. solani -- 5/31 -- 16.1%.

Table 2. Effect of R. solani isolates on yield and crown-rot rating of root-rot resistant selections and their respective parents.

<u>Variety</u>	<u>R. solani Isolates<sup>a</sup></u>							
	<u>RB-6</u>		<u>Rs 5</u>		<u>Rs 11</u>		<u>Rs 21</u>	
	<u>Rate</u>	<u>Yield</u>	<u>Rate</u>	<u>Yield</u>	<u>Rate</u>	<u>Yield</u>	<u>Rate</u>	<u>Yield</u>
FC 701/2	0.1	122.5	1.7	95.2	2.7	80.8	1.0	92.9
GW 674-56C	0.0	138.6	0.7	106.2	2.3	103.5	1.4	132.7
702/2	0.0	118.0	0.9	87.9	1.8	81.0	1.3	98.4
C 817	0.0	137.7	1.5	122.7	2.1	93.0	0.8	114.2

<sup>a</sup> RB-6 root-rot isolate, Rs 5, 11 and 21 crown-rot isolates.

LSD .05 = 22.1.

Table 3. The effect of isolate and inoculation technique on yield of resistant and susceptible selections.

R. solani Isolate												
Type inoculation	RB-6		Rs 1		Rs 4		Rs 5		Rs 21		Control	
	Ro-sette	Soil	Ro-sette	Soil	Ro-sette	Soil	Ro-sette	Soil	Ro-sette	Soil	Ro-sette	Soil
<u>Selection</u>												
FC 701/2	492.2 <sup>a</sup>	194.7	447.8	579.9	413.4	464.8	393.3	534.9	472.7	452.4	524.7	506.0
GW 674-56C	201.1	0.0	445.9	415.7	501.4	406.1	368.1	502.8	374.9	435.6	378.6	487.6
FC 702/2	279.6	15.7	420.8	367.6	424.1	489.8	415.6	482.1	329.1	473.5	439.3	490.2
C 817	267.8	0.0	416.5	451.6	437.9	487.8	474.1	487.9	366.1	356.3	402.0	428.0
FC 703	347.4	204.3	434.4	488.6	463.2	517.1	463.5	549.7	394.2	515.7	403.4	498.7

<sup>a</sup> Weights are in grams.

LSD .05 = 163.3.



Fig. 1

Noninoculated

Susceptible  
variety

Resistant  
variety

Inoculated

Resistant  
variety

Susceptible  
variety

(Notice smooth-  
ness and lack  
of scurf on  
the resistant  
variety)

## Effects of Fumigation, Fertilizer, Variety and Crop Rotation on Yield, Sucrose, and Purity of Sugarbeets

I. O. Skoyen and E. D. Whitney

The second year's results are reported of a three-year experiment designed to study the effects of soil fumigation on soilborne disease organisms, on increasing yield, and the effects on percent sucrose and purity. A detailed report of the experimental procedures and of the first year's results are presented in Sugarbeet Research, 1970 Report, pages B74-B80.

Materials and Methods: The factorial design for the 1971 test had three levels each for nitrogen and crop rotation, and two levels each for fumigation and varieties. A split-split plot field arrangement was also used for the 1971 test. Crop rotations were the main plots, fumigation treatments the sub-plots, and variety-fertilizer combinations sub-sub-plots. All treatments were completely randomized within each of the three blocks and within the sub-plots. Each block was a replication.

Nitrogen (N) fertilizer levels in 1971 were 99, 186 and 244 lbs. per acre (/A). Level one, applied preplant, included 53 lbs. P<sub>2</sub>O<sub>5</sub> and 25 lbs. K<sub>2</sub>O /A. A sidedress application of 87 lbs. N/A on levels two and three was made nine weeks after planting and the final application of 58 lbs. of N/A on level three, four weeks later.

The soil fumigation (with 67% methyl bromide - 33% chloropicrin), using commercial equipment, was made on March 19, 1971 at a rate of 370 lbs./A. The fumigant was injected 8 inches deep and a plastic tarp was laid over the treated area simultaneously with the injection. Soil temperatures were 53 F at the 8 inch depth. The plastic tarp was removed after three days.

Test varieties US H7A and US H9B were planted April 13 and thinned May 13-14, 1971. Six sub-plots were planted that were not used in analysis of the results in order to prepare additional treatment combinations for the 1972 test. Unplanted plots were again fallowed in 1971.

Frequent irrigations of short duration (by sprinkler system) were used to avoid runoff, to minimize possible contamination of treated strips, and as needed to maintain growth.

Plot size was the same as in the 1970 test, 4 rows wide by 27' long and with 3' alleys between plots. The two center rows were harvested and the roots weighed and analyzed for percent sucrose, ppm NH<sub>2</sub> nitrogen, ppm sodium (Na), ppm potassium (K), and impurity index. The test was harvested six months after planting.

### Results and Discussion

The test results were analyzed in three sets: 1) all data combined in which history-fumigation effects could not be separated; 2) as a two history - three fumigation factorial in the main plots; and 3) as a three history - two fumigation factorial in the main plots. The three history and two fumigation factorial analysis (set 3) is reported because it shows the essential differences that occurred in the 1971 test (Table 1). However, for factorial analysis, the test results of one 1971 fumigation treatment was included as equal to 1970-71 (2 year) fumigation treatments. Analysis of data comparing the results for the two years of testing has not been completed.

Main Effects: Significant yield differences occurred between most treatments for all main effects (Yr, F, Ft and V) for tons per acre (TPA) and gross sugar. The differences were comparable to those observed in 1970, page B78. Plots producing third-year-beets had significantly lower yields than that for plots in beets two years and one year respectively. Sucrose percentage in 1971, as in 1970, was significantly lower only for the high level of N (244 lbs./A). The gross sugar value for the highest N treatment shows that substantial losses in percent sucrose due to excess N are not compensated by increased tonnage. US H9B was superior to US H7A for TPA but percent sucrose was equivalent. The 186 lbs./A rate of N was optimum for the 1971 test, although sucrose was 0.3% point lower than the low level of N.

In 1971, differences in ppm  $\text{NH}_2$  N in the roots were observed only for fertilizer treatments and each increment of N produced significantly higher  $\text{NH}_2$  N. The ppm Na in the roots in 1971 was similar to that observed in 1970 except that there was no difference between fumigation treatments. US H7A again showed a significantly higher ppm Na than US H9B. Also, the high N treatments had significantly higher ppm Na. Significant differences occurred in all test variables for ppm K in the roots. Roots from plots in third-year-beets, roots from non-fumigated plots, roots of US H9B and N fertilizer levels 1 and 2, all had lower ppm K than that of corresponding treatments. The impurity index in 1971 showed significant differences only for fertilizer levels.

There were no differences due to replications in the 1971 test, indicating good test reliability.

Interactions: The comparison of years x fumigation (Yr x F) showed a significant association (5%) for both TPA and gross sugar. This occurred in the third-year-beet plots where fumigation increased root yield by 5.8 TPA over that of non-fumigated plots. The benefit from fumigation decreased to 2.3 tons for plots in beets two years and to 1.25 TPA for first year beet plots. Yields were nearly equivalent for all fumigation treatments regardless of beet history.

Years x variety (Yr x V) and fumigation x variety (F x V) showed no interactions in 1971, the same response as occurred in 1970. The three factor comparison of Yr x F x V showed a significant interaction only for ppm K (5%). US H9B showed consistently lower ppm K in the roots than US H7A over all treatment combinations but the greatest difference occurred in the non-fumigated plots in third-year-beets.

Years x fertilizer (Yr x Ft) and years x fumigation x fertilizer (Yr x F x Ft) analysis showed interactions for both gross sugar and TPA. The Yr x Ft interaction was similar to that observed in 1970, (page B79), in that the effect of fertilizer treatment was greatest in plots growing beets the longest. In plots with three years in beets 186 lbs. of N (level 2) increased yield 5.2 TPA and 244 lbs. of N (level 3) produced an additional 1.2 TPA, whereas for first year beets level 2 of N increased yield only 0.4 TPA and level 3 of N increased it 2.8 TPA. Level 3 of N consistently caused substantial reduction in percent sucrose. The Yr x F x Ft interaction in 1971 was also similar to that of 1970, however, in 1971, differences were highly significant for both gross sugar and TPA. Non-fumigated plots the third year in beets showed a yield increase of 10.3 TPA with level 2 of N (186 lbs./A) but level 3 of N (244 lbs./A) only produced an increase of 0.3 TPA. Fumigation combined with fertilization increased root yields the most for all rotations but the rate of increase was diminished compared to the increases due to fertilizer alone. Sucrose percentage decreased with each increase in N and ranged from 0.84% point to 1.51% point in the high level N non-fumigated plots. The combination of high level N and fumigation caused an additional decrease in percent sucrose and this ranged from 1.54 to 2.21 percentage points. In four of our six treatments, level 2 of N (186 lbs./A) had higher gross sugar than that for 244 lbs. of N. The fumigation x fertilization (F x Ft) comparison showed interactions for gross sugar, TPA, percent sucrose and ppm Na. The interaction for sucrose is a reflection of the adverse affect on sucrose that occurred with high nitrogen fertilization (244 lbs./A) for both non-fumigated and fumigated plots. Percent sucrose was depressed only slightly with the 186 lb. level of N. The F x Ft interaction for ppm Na in the roots reflects the significant increase in uptake of Na at the high level of N, 278 ppm in non-fumigated plots and 351 ppm in fumigated plots, compared with 195 and 197 ppm for these respective plots at the 99 lb./A level of N. At 186 lbs./A of N, root content of Na was about 45 ppm higher than that for the low level of N.

Comparisons of variety x fertilizer ( $V \times Ft$ ), years x variety x fertilizer ( $Yr \times V \times Ft$ ), fumigation x variety x fertilizer ( $F \times V \times Ft$ ), and years x fumigation x fertilizer x variety ( $Yr \times F \times Ft \times V$ ) showed no significant interactions in 1971.

It is obvious from the results that growing beets year after year has a depressing effect on yield, however, the cause (s) of reduction have not been apparent in two years of testing. Damping off has been minor and not restricted to any given treatment. Tests for root damaging fungi have continued to show these to be low in 1971, as they were in 1970. Root rotting during the growing season was also minor.

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The assistance of Dr. Gary V. Richardson, Biometrical Services Staff, Statistical Laboratory, Fort Collins, Colorado, in analyzing the test results, is gratefully acknowledged.

Table 1. Means, significance levels and interactions for the characteristics measured over the four test variables.

Treatments	Levels	Acre Yield			PPM			Impurity Index
		Pounds Gross	Tons Sugar	Beets	Percent Sucrose	NH <sub>3</sub> N	Na	
Years (Yr)	69-70-71	7650	24.3	15.80	693	222	1964	808
	70-71	8110	26.0	15.62	677	218	2168	839
	71	8280	26.7	15.53	649	219	2160	822
F value		4.29*	4.61*	1	1	1	10.63**	1
Fumigation (F)	Non	1	7540	24.1	15.70	670	208	805
	Fum 70-71		8480	27.3	15.61	676	231	841
F value			26.33**	22.46**	1	1	7.81*	1
Yr x F			4.88*	4.44*	1	2.08	1.24	5.54*
Error A		10						1
Variety (V)	US H7A	1	7810	25.0	15.69	657	246	824
	US H9B		8210	26.4	15.62	690	193	822
F value			8.45**	9.68**	1	1.73	19.20**	1
Yr x V		2	1	1	1	2.10	1	2.16
F x V		1	1	1	1	1	1	1
Yr x F x V		2	1	1	1	1	1	4.61*
Fertilizer (Ft)		2	7540	23.2	16.26	531	148	2036
(lbs. nitrogen)	99		8340	26.2	15.96	655	197	2097
	186		8160	27.7	14.74	833	315	2160
	244		12.75**	35.49**	86.50**	50.36**	67.27**	1011
F value							6.61**	87.79**
Yr x Ft		4	3.83**	3.73**	1	1	1	1
F x Ft		2	9.08**	4.54**	3.21*	1	4.25*	2.91
Yr x F x Ft		4	6.14**	6.14**	1.42	1	1	2.44
V x Ft		2	1	1	1.30	2.22	2.59	1.56
Yr x V x Ft		4	1	1	1	1	1	1.34
F x V x Ft		2	1	1	1	1	1.10	1
Yr x F x Ft x V		4	1	1	2.16	1	1.12	1
Error B								60

d = less than one

\* = 0.05

\*\* = 0.01

NEMATOLOGY INVESTIGATIONS

Orientation and development of Heterodera schachtii  
larvae on tomato and sugarbeet roots.

Arnold E. Steele

Variations from the typical pattern of development of Heterodera schachtii were reported by Strubell, who observed that larvae attacking very small roots frequently complete their development while attached by their heads only. More recent reports on H. schachtii biology have not indicated an ectoparasitic habit. Consequently, roots of sugarbeet (Beta vulgaris L., cultivar 'U.S. 75') and tomato (Lycopersicon esculentum, cultivar, 'Pearson A-1') were examined to determine the orientation of H. schachtii larvae. Fifty beet plants were grown from seed in, and 50 tomato seedlings in the cotyledon stage were transplanted to, individual 15 cm clay pots containing approximately 1400 cc of sterilized clay-loam soil and sand mixture to which had been added 50 H. schachtii cysts containing eggs and larvae. After growing in the greenhouse 14 - 117 days, the external surfaces of roots were examined for larvae and adult sugarbeet nematode. Second, third, fourth-stage larvae and young adults were found on the roots of sugarbeet and tomato plants and within roots. There was wide variation in the degree of larval penetration, ranging from completely endoparasitic to nearly completely ectoparasitic with only the cephalic region buried in the root. Larvae were often semi-endoparasitic and somewhat wrapped around the root. All of the sexually differentiated larvae external to the roots were males with the exception of a single third-stage female observed on a tomato plant. All other females found upon the roots or penetrating the roots were either fourth-stage or adult.

No regular pattern of distribution of nematodes on the roots was detected. They occurred singly or in groups of two or more. Groups contained males only or females only, or males and females together. At least a few immature males were found on the root surface of all plants examined. However, the numbers of third and fourth-stage males on the root surface never exceeded an estimated 10% of the total population on a given plant.

Adult females and early third, fourth, and early fifth-stage males within larval integuments were found external and attached to the lateral feeder roots of sugarbeets obtained from a commercial field at harvest. No larvae or adults were found on the surface of the large well-formed tap roots or on the larger branched roots of beets.

Two sugarbeet plants were selected at random from a group grown 22 days in soil infested with the sugarbeet nematode. The roots were examined to determine the position of the larvae on or within the roots. Nearly twice as many larvae were found on or within lateral

roots as were observed on tap roots of sugarbeet (94 and 58 larvae respectively). Forty-six percent of the larvae were oriented with their anterior ends toward the root tip, 44% with their anterior ends toward the hypocotyl, and 10% were oriented nearly perpendicular to the root axis.

These observations demonstrate that the sugarbeet nematode can occur external to the roots of sugarbeet. However, with but one exception, all larvae in early stages of development observed on root surfaces were males. Since all stages of males were found on the lateral roots of tomato and sugarbeet, it is likely that males typically develop semiednoparasitically on the external root surfaces of these plants. According to Strubell, the male emerges from the root only after it has emerged from its larval integument. In this study, however, late fourth stage males and young males were found within larval integuments attached to the root surfaces. In addition, adult males were seen to emerge from larval integuments attached to root surface.

Larvae oriented near the root surface are less likely to stimulate formation of syncytia which, in sugarbeet, are invariably formed within the stele of the lateral rootlets. Since males may complete their development at or near the root surface, factors restricting deep penetration of larvae, such as, development of a tough periderm in older roots, may favor the development of males over females.

#### Influence of storage temperatures on subsequent hatching and emergence of larvae in diffusate or tap water.

H. schachtii cysts from sugarbeets which contained eggs and larvae were placed in tap water, and stored 10 days at 6 C or 24 C and then treated for 15 days at 24 C with tap water or sugarbeet root diffusate diluted to 5% of its original concentration. Each treatment was replicated 6 times, and each replication included 5 cysts. In a similar test pre-treatment storage temperatures were 5 C or 24 C, and replications included 50 cysts treated 30 days with tap-water or with full-strength sugarbeet root-diffusate. Sugarbeet nematode cysts used in the later test were obtained from a population maintained 10 years on tomato (Lycopersicon esculentum, cultivar Pearson A-1).

Conflicting data were obtained from the two experiments. In one test, greater hatches of larvae occurred from cysts stored at 6 C, whereas in the other test, fewer larvae emerged from cysts stored at 5 C. In both tests only two storage temperatures were evaluated. Consequently, it could not be determined whether differences were due to stimulation or depression of hatching. Although in the latter experiment, storage temperatures and treatment solutions interacted to significantly influence emergence of larvae, the effect due to interaction was less than the separate effects.

Pretreatments with low temperatures have dissimilar effects on subsequent hatching and emergence of larvae from two groups of cysts. These cysts were obtained from populations of H. schachtii which differ in their ability to successfully parasitize susceptible Pearson A-1 tomato and resistant Nematex tomato. However, additional tests are needed to determine if the responses to low storage temperatures observed in the present test are characteristic of these physiologically distinguishable isolates of the sugarbeet nematodes.

Table 1. Influence of storage temperatures on subsequent matching and emergence of larvae from cysts after 15 days in diffusate or tap water.

Treatment Solution	Larval Hatch		Mean of Solutions
	Storage Temperature 6 C	24 C	
Beet Root Diffusate	450 <sup>2/</sup>	230	340
Tap Water	223	78	151
Mean of Temperatures	337	154	
Source	d.f.	Mean Square	F.95
Solutions (A)	1	215,272	10.29
Temperature (B)	1	199,655	9.54
Interaction (A x B)	1	8,626	0.41
Error	20	20,931	N.S.

<sup>1/</sup> Cysts stored 10 days at indicated temperature followed by treatment at 24 C.

<sup>2/</sup> Mean of 6 replications each consisting of 5 cysts.

Table 2. Influence of storage temperatures on subsequent hatching and emergence of larvae from cysts after 30 days in diffusate or tap water.

Treatment Solution	Storage Temperature <sup>1/</sup>		Mean Solutions
	5 C	24 C	
Beet Root Diffusate	3,122 <sup>2/</sup>	6,060	4,591
Tap Water	777	2,614	1,695
Mean of Temperatures	1,949	4,337	

Source	d.f.	Mean Square	F.95
Solutions (A)	1	50,320,896	121.16 **
Temperature (B)	1	34,210,488	82.37 **
Interaction (A x B)	1	18,172,200	43.75 **
Error	20	415,305	

<sup>1/</sup> Cysts stored 10 days at indicated temperature followed by treatment at 24 C.

<sup>2/</sup> Mean of 6 replications each consisting of 50 cysts.

Influence of inoculum level on the sex ratio of  
H. schachtii on sugarbeet and tomato

The 1970 Annual Report of this laboratory presented data which demonstrated that production of cysts was not significantly increased on sugarbeet by increasing the inoculum from 20 to 60 cysts/plant. Increasing the inoculum from 20 to 40 cysts/plant resulted in a significant increase of male sugarbeet nematode whereas a significant increase in females was not obtained. This report contains additional studies of factors influencing the sex ratio H. schachtii.

In two separate tests Heterodera schachtii cysts were inoculated at rates of 20 or 60 cysts/plant on sugarbeet (test #1) or tomato (test #2). Plants were grown in a growth chamber in high intensity illumination for 16 hours/day. Diurnal temperatures were adjusted to maintain the soil temperature at 24° C ± 1. Plants were inoculated with the contents of broken cysts and grown 18 days after which the plants were washed and placed in glass funnels with the roots only immersed in tap water.

Approximately 10 ml of water was drained from each funnel every other day and the water examined for mature male sugarbeet nematode. Males were collected from sugarbeet for 22 days after harvest whereas males were collected from tomato for 28 days after harvest. Sugarbeet and tomato plants were also harvested 30 days after inoculation and examined for mature female sugarbeet nematode. Counts appear in tables 3 and 4.

Data demonstrated that males but not females are significantly increased on tomato or sugarbeet when the inoculum is increased from 20 to 60 cysts/plant. These tests will be repeated under similar conditions.

Influence of population source on development  
of H. schachtii on tomato

Research at this laboratory has established that prolonged association of the sugarbeet nematode with tomato resulted in the selection of a nematode isolate or biotype that parasitizes Pearson A-1 tomato and resistant Nematex tomato in larger numbers than populations not previously associated with tomato. Data in these tests were obtained for females only. The present list attempted to measure the relative numbers of male and female sugarbeet nematode developing on Pearson A-1 tomato.

H. schachtii cysts were obtained from pot cultures on sugarbeet or tomato and inoculated on transplanted Pearson A-1 tomato seedlings at the rate of 50 cysts per plant. Plants were grown in a chamber equipped with high intensity illumination and maintained at 24° C. The plants were harvested 18 days after inoculation and incubated in funnels for a period of 30 days to obtain adult male

Table 3. Influence of inoculum level on nematode populations and weights of sugarbeet inoculated with *H. schachtii*

Number of Cysts Inoculated	Plants Harvested 18 Days After Inoculation			Plants Harvested 30 Days After Inoculation		
	Mean Plant Weight (gms)	Mean No. Males/Plant	Mean Plant Weight (gms)	Mean No. Females/Plant	Mean No. Females/Plant	Mean No. Females/Plant
				1/	2/	
20	8.4	1/	168	24.0	312	
60	6.6	435	21.3	532		
Significance				N.S.	N.S.	N.S.
1/	Each figure is a mean of 10 plants.					

Table 4. Influence of inoculum level on nematode populations and weights of tomato inoculated with *H. schachtii*

Number of Cysts Inoculated	Plants Harvested 18 Days After Inoculation			Plants Harvested 30 Days After Inoculation		
	Mean Plant Weight (gms)	Mean No. Males/Plant	Mean Plant Weight (gms)	Mean No. Females/Plant	Mean No. Females/Plant	Mean No. Females/Plant
				1/	2/	
20	4.79	1/	629	6.28	457	
60	3.10	1613	3.05	445		
Significance				N.S.	N.S.	N.S.
1/	Each figure is a mean of 10 plants					

sugarbeet nematode. Another group of plants were harvested at 31 days and examined for mature females.

Four replications of 50 cysts from each population were exposed to sugarbeet root diffusate for a period of 5 weeks to obtain an estimate of the infection potential of each population. All data of this test are listed in table 5.

When the nematode counts are adjusted to values based on larval hatches of the inocula, it can be seen that nearly twice as many males developed on tomato inoculated with populations from tomato as did on tomato inoculated with cysts obtained from beet. However more than 21 times as many females developed on tomato parasitized by sugarbeet nematode from tomato. This suggests that females may possess a greater 'biovariation' that is readily subject to selection pressures of host-plant origin. This test will be repeated except that amount of inocula of the two populations will be nearly equal.

#### Influence of a sugarbeet nematode biotype on cultivars of tomato resistant to root knot nematode species

The 1969 Annual Report of this laboratory reported the results of three tests which demonstrated that Nematex, a tomato cultivar resistant to root knot nematode, also possessed a degree of resistance to the sugarbeet nematode. However, this cultivar was less resistant to a biotype of H. schachtii maintained continuously on PEARSON A-1 tomato for a period of 10 years.

To obtain additional information on the nature of resistance of tomato to H. schachtii, additional tomato varieties and/or experimental lines were obtained for testing for intraspecific variability; seven of these varieties have been tested and eight additional varieties are being tested.

Sugarbeet nematode cysts were obtained by washing and screening infested soil from pot cultures of infected sugarbeet. The nematode cysts were broken open and the contents inoculated at the rate of 50 cysts per plant. Two separate tests were conducted. Each test contained 8 replications of each tomato variety.

Forty-four days after inoculation, the tomato plants and soil were washed to recover mature females and cysts. Fresh weights of tops and roots of tomato were obtained when the growing period was terminated. Data of these tests are listed in table 6. Nematode counts were analyzed for statistical significance by the ANOVA method.

In the first test there was no significant differences between varieties as to the numbers of cysts found on the roots. However,

Table 5. Influence of population source on hatching and development of nematode and weights of tomato

Population	Plants harvested 18 days after inoculation			Plants harvested 31 days after inoculation		
	Mean larval hatch in diffusate	Mean plant weight (gms)	Mean No. males/plant	Mean plant weight (gms)	Mean No. females/plant	Mean No.
Beet	104	12.48	2/	234	17.12	26
Tomato	220	10.94		877	18.77	1167
Significance			N.S.	**	N.S.	**

1/ Each figure is the number of larvae hatched per cyst from 4 replications of 50 cysts.

2/ Mean of 10 plants inoculated with 50 cysts from tomato or sugarbeet.

in the second test, significant differences were apparent. In this test plants average greater top and root weights resulting from higher greenhouse temperatures. It is of interest to note that when nematode data was grouped by test, the numbers of nematodes per gram of root was the same for both tests. In both tests ANAHU 083003 supported the highest populations, Nematex the lowest, with PEARSON A-1 exhibiting resistance intermediate to these varieties. This project will be continued.

Table 6. Plant weights and nematode counts 44 days after inoculation of tomato varieties with Heterodera schachtii 1/

Tomato Cultivar	Test No. 1				Test No. 2			
	Mean plant wt.		Nemas per gm. of root		Mean plant wt.		Nemas per gm. of root	
	Tops	Roots	Tops	Roots	Tops	Roots	Tops	Roots
Pearson A-1	34.1	28.4	554	20.4	48.7	37.7	687	18.1
Nematex	34.8	29.8	357	12.9	39.4	37.3	-262	7.1
VFN8 Lot 10066	33.3	28.8	396	14.5	45.2	36.5	813	24.4
VFN8 Lot 206 300 34.6		26.7	455	18.0	44.9	33.5	685	21.5
ANAHU 083 003	32.1	28.2	615	21.1	43.5	36.5	900	24.8
ANAHU LS-10	34.8	28.7	569	20.2	43.6	37.2	888	27.5
ANAHU M1 M1	35.1	27.6	542	20.5	48.1	36.5	574	16.9
NO3-1 M	35.3	29.4	498	16.9	44.8	38.1	367	10.2
Y 207	<u>37.4</u>	<u>26.8</u>	<u>415</u>	<u>16.5</u>	<u>42.6</u>	<u>31.2</u>	<u>427</u>	<u>13.4</u>
Mean	34.6	28.3	489	17.9	44.5	40.6	623	17.9
Significance			N.S.	N.S.			**	**
LSD .05 1/			-	-	263	9.1		

All data are mean values of 8 plants.



## SUGARBEET RESEARCH

1971 Report

### Section C

Crops Research Laboratory, Logan, Utah

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SUMMARY OF RESEARCH ACCOMPLISHMENTS  
Logan, Utah - 1971

Plant Pathology  
(D. L. Mumford)

Curly top virus was artificially transmitted to sugarbeet by an injector instrument used to introduce a jet stream of beet juice containing the virus into the crown of the beet. Fifty percent infection was obtained when 48-day old plants were inoculated.

No isolates of curly top virus were found in 1971 that were as virulent as Utah isolate 66-10.

Beet yellow-vein virus was more prevalent in the Pacific Northwest than in the previous year.

Seventeen-hundred rows of sugarbeet breeding lines were evaluated for resistance to curly top virus. A highly significant correlation coefficient of .78 was obtained between results of field and greenhouse evaluations.

Below-seed and side-dress applications of the nematicide-insecticides aldicarb and carbofuran were as effective as phorate in killing sugarbeet leafhoppers during 3-4 weeks after application. Below-seed applications of carbofuran and phorate remained effective about 2 weeks longer than aldicarb.

Physiological Genetics  
(D. L. Doney)

Mitochondrial Respiration

Techniques have been developed for the isolation and measurement of oxidative phosphorylation of tightly coupled mitochondria from sugarbeet root.

Five different groups of hybrids and inbreds were assayed for mitochondrial efficiency (ADP:O ratios) and mitochondrial complementation for heterosis.

Inbreds that had been photo-thermally induced or were in the bolting (flowering) stage of growth exhibited some complementation for heterosis, i.e. ADP:O ratios of 1:1 mixtures were higher than the mean of the component inbreds and the size of this increase was related to the heterosis of the respective hybrids. The complementation, however, was small and not large enough to make unbiased decisions. Inbreds

sampled during two periods of very rapid growth and after being stored at 5 C, gave complementation equal to or less than the mean of the two inbred components. However, the complementation of samples taken at the fastest stage of growth (although small) were correlated with heterosis for the respective hybrids.

Mitochondria isolated from roots during the fastest stage of growth were excellent and were most efficient and rapid in oxidative phosphorylation measurements. Of the two sets of hybrids tested, mitochondrial oxidation efficiency (ADP:O ratios) was correlated with yield in one set but not in the other set.

Mitochondrial complementation for heterosis appears to be a factor in sugarbeet at certain stages of growth. However, at no stage was this phenomenon very strong. Differences in complementation were small and would require excessive replication to detect true differences.

#### Isozyme Studies

Isozymes of Glucose-6-phosphate dehydrogenase (G-6-DP) were separated by the method of electrophoresis. A different isozyme pattern was observed in immature anthers of a CMS line from a sister fertile line.

#### Plant Physiology (Roger Wyse)

The storage characteristics of twenty-one sugarbeet varieties were evaluated as part of a continuing study to develop a technique for rapidly determining the storage potential of varieties at harvest.

Changes in the activity of several key enzymes and the content of non-sucrose compounds during short term storage of 14 and 28 days at 5 and 25 C was determined. These changes are now being correlated with the long term storage characteristics of these varieties.

The respiration rates of the same 21 varieties varied over a 1.5 fold range in 1971 as compared to a 2.5 fold in 1970. Eight varieties studied extensively last year were included again this year. It now appears that the variation between years may be nearly as great as the differences between varieties. For example, a variety showing the lowest respiration rate in 1970 ranked seventh in 1971. The factor(s) controlling the respiration rate of individual varieties at 5 C appears to differ. For example, in some varieties, surface area correlates very well with respiration rate, but in others it does not.

A preliminary study of the enzymes of sucrose synthesis accumulation and degradation throughout the growing season was begun. As expected,

the enzymes of sucrose degradation in the root decrease late in the season while those involved in sucrose accumulation increase. This study will be continued this growing season. The objective of this research is to develop a better understanding of the mechanism of sucrose accumulation late in the growing season. The ultimate goal will be to develop methods of artificially controlling sucrose accumulation without using the "shotgun" approach to screen potential regulating chemicals.

A non-aqueous technique was developed for applying chemicals to sugarbeet seeds.

The percent germination of seeds soaked 24 hours in acetone was not significantly different from untreated controls. Thus, acetone can be used as a solvent to impregnate "dry" seeds with various growth regulating substances. Several compounds applied to sugarbeet seeds using this method increased seedling emergence by as much as one day.

#### Genetics and Breeding

(J. C. Theurer)

#### Inheritance and Linkage Studies in Sugarbeets

During 1971, 12 new mutants were isolated in homozygous condition and crosses were made with genetic markers.  $F_1$  progenies with six mutants resulted in normal phenotype.  $F_2$  segregation of progenies involving S, a, R, ru, Tr, and ch genes were partially evaluated for linkage associations.

#### Inheritance of New Sources of Male Sterility

Three sources of male sterility were investigated to determine their inheritance. All three were genetic and appeared to be identical to a, male sterility.

#### Further Attempts to Develop Haploid Sugarbeet Plants from Pollen

Eight different media were used in tissue culture of anthers. Some swelling of anthers occurred but no development of plantlets occurred over a 45-day period of incubation.

#### Further Study of Variation in Partial Male Fertility

Male-sterile plants derived from seed resulting from reversion of a small branch on a single plant to pollen fertility, were crossed for two generations to the annual SLC 03. All progenies remained 100%

male sterile. Even though plants were cut back and permitted to develop new seedstalks for 2-3 months, until the plant died, no further evidence of reversion was detected.

#### Linkage and Inheritance Studies Involving an Annual Pollen Restorer and Other Genetic Characters in Beta vulgaris

An annual pollen-restorer inbred was developed from a sugarbeet CMS X table beet cross by repeated selection for fertility for four generations. Genetic tests indicated that restoration was due to genetic factors and not to reversion of the plasm from sterile to normal. The pollen-restorer gene showed independence of the Y-R-B linkage group. Linkage tests of the pollen restorer and other marker stocks will be determined in January and February, 1972.

#### Studies using Ethrel as a Gametocide for Sugarbeet

Four varieties of sugarbeet were treated with four concentrations of ethrel at different stages of seedstalk development. The concentrations were 200, 500, 1000, and 3000 ppm. Stages of development when treatments were made were: seedstalk just initiated 1-2 inches, 6-inch seedstalk, early bud, advanced bud. Treatments were made by three methods: spraying leaves to run off, midvein feeding, and injection with a hypodermic needle. The 3000 ppm dosage was highly phytotoxic and the 1000 ppm gave similar results for some treatments. Varieties differed in their reaction to this chemical. Although the degree of fertility was reduced with certain treatments, the practical use of this chemical as a gametocide for sugarbeets is questionable.

#### Variety Trials

Test 1 Eleven single crosses, three related 3-way hybrids and 9 related double-cross hybrids were grown at Logan and Farmington. The 4-way hybrids had higher gross sugar than 3-way or single-cross hybrids. Sugar percentage and impurity index values were similar for all hybrid classes. Performance of three 3-way hybrids and three 4-way hybrids could not be predicted from single-cross averages.

Test 2 Yield differences for reciprocal single-cross hybrids were due to differences in stand. Hybrids with Ovana as a male parent had higher sugar percentage than those with Ovana as a female parent. Five hybrids at Logan had significantly lower impurity-index values than their reciprocal.

Test 3 Month-old transplanted sugarbeets yielded significantly more gross sugar than seeded plots. Two-week old transplanted seedlings also had higher gross sugar, but differences were not significant.

Transplanted plots had sprangled roots and higher impurity than seeded beets. There was no difference in sugar percentage between the transplants and seeded treatments.

Test 4 Five genotypes differing in yield and percent sugar potential grown under three different nitrogen levels were assayed for a number of quality factors. Genotype (Ov CMS X 0198S) reacted most adversely while genotype (UI Hybrid B) was most tolerant to increasing nitrogen levels for percent clear juice purity and total amino acids. Genotype (Ov CMS X CT9) responded most to increasing nitrogen levels for yield.

It appears that genotypes can be selected that are relatively tolerant to high nitrogen levels.

Test 5 Genotypic competition for quality and yield was measured for 3 genotypes at 3 different plant populations. Genotypes reacted similarly to competition. As the competition decreased (decrease in plant population) the quality factors (index, nitrogen, sodium and potassium) increased even though there was no change in gross sugar, root yield or percent sugar.

Test 6 An evaluation of 25 pollen-restored double-cross hybrids was made at two locations. Six of the seven highest yielding hybrids had Ovana or L-53 (an Ovana derivative) as a parent. (EL 31 X 129 Rf) and (Ov.2 X 129 Rf) were pollinators of hybrids having the highest gross sugar and sugar percentage. The best hybrids in the test were equal in performance to the best check variety, UI Hybrid D.

Test 7 Twelve new inbreds were evaluated as pollinators. Specific combining ability was noted for yield and sugar percentage. Inbreds 75106, 75123, 29.008 and 27.53 were parents of high-tonnage varieties. Two of these inbreds, 75123 and 27.53, were also pollinators that exhibited high sugar percentage and low impurity index.

Test 8 In a test of 40 inbreds SLC 129 had the highest gross sugar. As expected, L-19 was far superior to other inbreds for sugar percentage. SLC 132, F.C. 601, L-13 and SLC 133 were low in sugar percentage. Inbreds 27.53, CT5, F.C. 601, L-19, L-36 and 28.19 were inbreds having low impurity index values. SLC 129, F.C. 601 CMS, and AI-12 CMS yielded significantly higher than their equivalent CMS and pollinators inbreds, respectively.

Test 12 The technique of selecting individual beets early in the growing season was evaluated in a space-planted (2 feet apart) trial of 48 segregating lines. Measurements were made on individual plants on July 14 and at harvest time (September 20). Correlations between means and variances of measurements of July 14 were made with those at harvest time. Root width, root weight and total plant weight at July 14

were correlated with yield at harvest time. Variances between the early and harvest date measurements were not related. Further tests are necessary to ascertain the merits of early selection.

Test 13 Selections made from individually spaced plants in 1968 showed superiority over their parents in both yield and percent sugar. These selections were also tested in 1970 and showed similar results.

Test 14 Individual beet selections were made in three heterogenous populations, 0457, 9229 and 0453, in 1968 and sibbed and selfed progenies were evaluated this year in replicated field trials. All selections except one were lower in gross sugar and tonnage than the respective parent population. Population 9229 consistently showed evidence of positive selection pressure for high index and low sugar. Population 0453 selections showed no effects from selection pressure. Differences in population 0457 parents and progenies were not consistent with the selection pressure exerted. It doesn't appear that higher sugar percentage or lower impurity index could be attained by further individual beet selection in these populations.

Variety Tests, Logan and Farmington, Utah, 1971

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**SOIL TYPES:** Silty loam on the Utah State University North Farm at Logan and sandy loam on the Farmington Farm.

**PREVIOUS CROPS:** The area planted on the North Farm consisted of three adjacent sections of land numbered 5, 6, and 7. In 1970 sections 5 and 6 were in cereal grains while section 7 was planted in vegetable crops (tomatoes and beans).

The area planted at the Farmington Farm was leveled in the fall of 1965 and has been summer fallowed since then.

**FERTILIZER:** North Farm: received 800 pounds per acre of 16-20-0 and the Farmington Farm: received equivalent of 500 pounds 24-20-0 per acre harrowed in before planting. The Farmington Farm also received a side-dressing of 80 pounds nitrogen on July 19, 1971.

**PLANTING DATES:** Farmington Farm: April 14, 1971.  
North Farm: May 10, 1971. (All tests at North Farm and Farmington Farm were planted in two-row plots 37 feet long).

**THINNING DATES:** Farmington Farm: May 17, 1971.  
North Farm: June 12, 1971.

**IRRIGATIONS:** North Farm: sprinkled after planting, after thinning, and on a weekly schedule until two weeks before harvest.  
Farmington Farm: furrow irrigated approximately at weekly intervals, as needed, to keep the field on the damp side throughout the season until two weeks before harvest.

**HARVEST DATES AND PROCEDURES:** North Farm: October 12 to 15, 1971.  
Farmington Farm: November 10 to 19, 1971.

Tops were removed with a rotobeater and scalped with tractor-mounted scalping tools supplemented by long-handled hoe trimming to assure a complete topping job. Beets in plots were counted when put into the weighing basket on the harvester. A ten-beet sample was taken at random from the harvester table from each row of the two-row plots for sugar analysis, and all beets in the plot were weighed to determine root yield.

EXPERIMENTAL DESIGN: Test 1 Performance and prediction of 2, 3, and 4-way hybrids: This test was planted at both locations with 28 entries and 5 replications in a randomized-block design (RBD).

Test 2 Reciprocal crosses: Twenty entries were planted at the North Farm in a RBD of 6 replications. At Farmington this test consisted of 14 entries with 6 replications in a RBD.

Test 3 Transplanting vs seeding: We planted this test in a split-plot design of 4 replications with 4 entries (commercial varieties) as whole plots. There were 3 treatments: (1) transplants one-month old, (2) transplants two-weeks old and (3) direct seeded. Plots in this test were 4 rows wide but only the center two rows were harvested.

Test 4 Genotype times nitrogen interaction: This test consisted of 5 entries in a split-plot design of 6 replications with 3 fertilizer levels as whole plots. Fertilizer levels were: (1) Zero N (2) 120 lbs N, harrowed in before planting and (3) 240 lbs N, one-half harrowed in before planting and one-half side dressed July 12, 1971.

Test 5 Genotypic competition: In order to measure genotypic competition 4 genotypes varying in yield and percent sugar potential were planted at 3 plant populations in a split-plot design of 6 replications. Plant populations (whole plots) were 23,000, 34,500, and 46,000 plants per acre.

Test 6 Evaluation of double-cross hybrids: Thirty-one hybrids were tested at both locations in a randomized-block design of 6 replications.

Test 7 Evaluation of new pollinator inbreds: A randomized-block design of 5 replications of 41 hybrids was used to evaluate 12 inbreds.

Test 8 Inbred lines: This test was composed of 40 entries in 3 replications of a randomized-block design.

Test 12 Selection techniques (Individual roots): Forty-eight segregating lines were divided into 6 groups and each group planted in a completely randomized design. Plots consisted of 17 beets planted 2 feet apart in rows 22 inches apart. One check plant (UI 7) was planted at random in each plot.

Test 13 Nematode selections: This test was planted at Farmington in a randomized-block design. There were 12 entries and 6 replications.

Test 14 Individual beet selections: A randomized-block design of 18 entries and 4 replications was used to test sibbed selections. Selfed progenies had 22 entries and were planted in a separate randomized-block design of 4 replications.

TEST 1

Performance and prediction of 2, 3, and 4-way hybrids

Eleven single crosses, three related 3-way hybrids, nine related double crosses, and six check varieties were grown in Test 1 at Logan and Farmington this year. Comparison was made of the average performance of each type of cross. Yield, sugar percentage, and quality factors for each 3 and 4-way hybrid were compared as far as possible with the average performance of the component single crosses.

At Logan there were no significant differences between the entries for gross sugar, tonnage or impurity index. The average gross sugar of the 3 and 4-way hybrids exceeded that of the average of the single crosses (table 1-1). The 4-way hybrids, on the average, were significantly superior to the single crosses for gross sugar. These hybrids also averaged significantly higher sugar percentage than the single crosses or 3-way hybrids.

Index values for the 4-way crosses were about equal to the 3-way and significantly lower than that for the single crosses. Thus, the double-cross hybrids, on the average, gave better performance.

There were significant differences for all variables except for amino N at the Farmington location (table 1-2). The average gross sugar for the 4-way hybrids was significantly higher than for the single crosses and tonnage for the 3-way crosses was significantly higher than for single crosses. Sugar percentage and impurity index values were similar for the three types of hybrids.

The 4-way hybrid (AC CMS X NB-1) X (CT9 X 129 Rf) had the highest gross sugar in the test. This variety significantly outyielded the highest yielding check variety, UI Hybrid D.

Comparison of hybrid performance with the average of component single crosses is given in table 1-3. Both the average of the non-parental single crosses and the average of all single crosses overestimated the actual yield of two of the 3-way hybrids and underestimated the gross sugar and tonnage for the other 3-way hybrid at Logan. The sugar percentage for all three hybrids and index values for two of the hybrids were estimated quite accurately by single-cross averages using either method. The differences between actual gross sugar, tonnage, and index values for non-parental single crosses vs 3-way hybrids were significant.

At Farmington the averages of non-parental and all single-cross components of hybrid Ov X (133 X 201 Rf) were significantly lower than the actual yield of 38.8 tons of beets and 11,139 pounds of gross sugar. The average of all single crosses in the Ov X (CT9 X 201 Rf) hybrid significantly exceeded the tonnage and was lower in sugar percentage than the actual performance of its hybrid. Impurity index values of single crosses were quite similar to their respective hybrids.

The ranking of the three 3-way hybrids could not be predicted by single-cross averages by either method with the exception of the non-parental single-cross method for impurity index at Logan.

Table 1-1. Performance prediction variety trial, Logan, Utah, 1971 (28 entries, 5 reps)

Description	Acre Yield		Percent Sugar	Index	PPM		K	Beet Count
	Gross Sugar	Tons Beets			Amino N	Na		
Ov CMS X EL 31	6,827	22.48	15.01	428	291	124	1,210	71
" X CT9	7,400	24.32	15.20	483	292	139	1,573	73
" X 133	5,536	17.92	15.44	489	352	164	1,374	58
" X 129 Rf	6,982	22.41	15.57	393	253	111	1,280	74
" X 201 Rf	6,542	21.22	15.42	448	286	99	1,476	69
AC CMS X CT9	6,851	21.85	15.66	471	337	132	1,409	73
" X 133	6,155	19.51	15.74	411	277	188	1,209	54
" X 201 Rf	6,493	20.73	15.67	440	303	122	1,367	70
CT9 CMS X 129 Rf	6,489	20.36	15.94	385	241	114	1,326	76
" X 201 Rf	6,803	22.08	15.46	479	281	118	1,663	78
133 CMS X 201 Rf	6,656	21.62	15.40	412	266	138	1,284	64
Mean of single crosses	6,612	21.32	15.50	440	289	132	1,379	69
Ov CMS X (CT9 X 201 Rf)	6,457	21.05	15.35	430	260	106	1,453	78
" X (CT9 X 129 Rf)	6,631	21.62	15.33	407	285	116	1,196	76
" X (133 X 201 Rf)	7,057	22.67	15.57	381	239	118	1,253	80
Mean of three-way crosses	6,715	21.78	15.42	406	261	113	1,301	78
(Ov X EL 31) X (CT9 X 201 Rf)	7,321	23.17	15.80	444	289	136	1,453	82
" X (CT9 X 129 Rf)	7,395	23.66	15.62	459	325	134	1,382	82
" X (133 X 201 Rf)	7,573	23.56	16.09	372	279	112	1,124	81
(AC CMS X NB-1) X (CT9X 201 Rf)	6,725	21.52	15.62	374	248	125	1,166	83
" X (CT9 X 129Rf)	6,670	21.12	15.80	399	276	155	1,199	80
" X (133 X 201RF)	6,699	20.50	16.36	356	241	149	1,155	79
(Ov X NB-1) X (CT9 X 201 Rf)	7,077	22.08	16.03	379	237	119	1,315	74
" X (CT9 X 129 Rf)	7,179	22.64	15.86	436	308	140	1,331	75
" X (133 X 201 Rf)	6,986	22.21	15.72	368	245	119	1,169	77
Mean of four-way crosses	7,069	22.27	15.88	399	272	132	1,255	79

Table 1-1. (continued)

Description	Acre Yield		Percent Sugar	Index	Amino N	PPM Na	PPM K	Beet Count
	Gross Sugar	Tons Beets						
UI Hybrid B	7,311	22.84	16.01	403	296	121	1,230	75
UI Hybrid D	7,934	24.65	16.09	322	223	108	1,032	84
Tasco Hybrid #1	6,437	20.46	15.73	387	258	94	1,270	80
Tasco Hybrid #3	6,826	22.34	15.26	379	216	133	1,266	86
US 22/3	7,079	22.51	15.74	526	380	154	1,567	84
Mean of all varieties	6,860	21.90	15.66	417	278	128	1,312	76
S.E. of mean	390	1.18	0.26	27.7	28.4	12.9	81.2	3.14
L.S.D. (5% point)	NS	NS	NS	77	79	36	227	9
Calculated F	NS	NS	NS	2.86**	1.86**	2.53**	3.30**	5.70**

\*\* Significant at 1% level

Table 1-2. Performance prediction variety trial, Farmington, Utah, 1971 (28 entries, 5 reps)

Description	Acre Yield			Percent Sugar			Amino N			PPM			Beet Count
	Gross Sugar	Tons Beets	Index	Index	N	Na	Index	N	Na	K	Index	N	
Ov CMS X EL 31	10,769	36.07	14.93	501	269	188	1,644	60					
" X CT9	10,854	38.41	14.19	564	279	213	1,772	67					
" X 133	9,440	32.74	14.37	542	291	237	1,624	58					
" X 129 Rf	9,786	31.95	15.32	433	248	134	1,457	64					
" X 201 Rf	10,203	34.55	14.81	472	233	143	1,658	63					
AC CMS X CT9	9,506	31.91	14.90	442	202	166	1,587	63					
" X 133	8,681	28.94	14.99	506	265	270	1,600	49					
" X 201 Rf	10,232	33.20	15.42	463	253	138	1,650	67					
CT9 CMS X 129 Rf	10,441	35.11	14.88	473	224	147	1,714	72					
" X 201 Rf	11,478	39.74	14.44	531	228	183	1,894	69					
133 CMS X 201 Rf	10,359	34.92	14.82	454	222	179	1,547	53					
Mean of single crosses	10,159	34.32	14.82	489	247	182	1,650	62					
Ov CMS X (CT9 X 201 Rf)	10,172	33.43	15.22	491	264	161	1,707	62					
" X (CT9 X 129 Rf)	10,677	36.73	14.57	486	220	163	1,699	77					
" X (133 X 201 Rf)	11,139	38.48	14.46	502	226	225	1,669	69					
Mean of three-way crosses	10,663	36.21	14.75	493	237	183	1,692	69					
(Ov X EL 31) X (CT9 X 201 Rf)	10,526	36.66	14.41	558	289	202	1,751	67					
" X (CT9 X 129 Rf)	10,986	37.39	14.71	517	276	190	1,667	76					
" X (133 X 201 Rf)	9,981	34.03	14.68	444	212	211	1,454	67					
(AC CMS X NB-1) X (CT9 X 201 Rf)	10,623	36.01	14.77	460	207	181	1,620	72					
" X ( " X 129 Rf)	11,762	35.34	14.98	492	257	188	1,640	70					
" X (133 X 201 Rf)	9,734	32.77	14.92	462	210	253	1,550	64					
(Ov X NB-1) X (CT9 X 201 Rf)	11,002	36.63	14.99	486	254	182	1,622	63					
" X ( " X 129 Rf)	10,619	35.64	14.92	411	190	179	1,449	66					
" X (133 X 201 Rf)	9,856	32.77	15.08	486	267	214	1,545	59					
Mean of four-way crosses	10,565	35.25	14.83	480	240	200	1,589	67					
UI Hybrid B	9,563	32.21	14.86	452	223	211	1,494	69					
UI Hybrid D	10,372	33.76	15.38	413	234	151	1,380	72					

Table 1-2. (continued)

Description	Acre Yield			PPM				Beet Count
	Gross Sugar	Tons Beets	Percent Sugar	Index	Amino N	Na	K	
Tasco Hybrid #1	9,924	32.77	15.12	379	186	122	1,380	73
Tasco Hybrid #3	10,196	34.32	14.84	424	203	152	1,475	74
US 22/3	8,378	28.86	14.52	521	246	215	1,736	61
Mean of all varieties	10,259	34.48	14.84	477	238	186	1,607	66
S.E. of mean	445	1.25	0.23	28.41	25.38	18.52	63.57	2.88
L.S.D. (5% point)	1,246	3.50	0.63	8.0	NS	52	178	8
C.V. Percent	9.70	8.12	3.40	13.31	23.80	22.31	8.85	9.77
Calculated F	2.88**	4.37**	1.88*	2.51**	NS	3.90**	3.73**	5.31**

\* Significant at 5% level

\*\* Significant at 1% level

Table 1-3. Comparison of actual 3-way and 4-way hybrid performance with the average of their component single crosses.

Description	Gross Sugar			Tons Beets			Sugar Percentage			Index	
	Non			Non			Non				
	parent	All single cross	All single cross	parent	All single cross	All single cross	parent	All single cross	All single cross		
<b>3-way hybrids</b>											
Logan:											
0v X (CT9 X 201 Rf)	6971	6915	6457	22.77	22.54	21.05	15.31	15.36	15.35	466	
0v X (CT9 X 129 Rf)	7191	6957	6631	23.36	21.62	15.38	15.57	15.33	15.38	438	
0v X (133 X 201 Rf)	6039	6245	7057	19.57	20.25	22.67	15.43	15.42	15.57	468	
Farmington:											
0v X (CT9 X 201 Rf)	10528	10845	10172	36.48	37.57	33.43	14.50	14.48	15.22	518	
0v X (CT9 X 129 Rf)	10320	10360	10677	35.18	35.16	36.73	14.76	14.80	14.57	498	
0v X (133 X 201 Rf)	9822	10001	11139	33.64	34.07	38.48	14.59	14.67	14.46	507	
<b>4-way hybrids</b>											
Logan:											
(0vX EL31)X(CT9 X 201)	6815	7321	22.28	23.17	15.24	15.80	15.80	15.80	15.80	454	
(0vX EL31)X(CT9 X 129Rf)	6658	7395	21.42	23.66	15.48	15.62	15.62	15.62	15.62	406	
(0vX EL31)X(133 X 201Rf)	6742	7573	22.05	23.56	15.20	16.09	16.09	16.09	16.09	372	
Farmington:											
(0vX EL31)X(CT9 X 201)	11124	10526	37.90	36.66	14.68	14.41	14.41	14.41	14.41	516	
(0vX EL31)X(CT9 X 129Rf)	10605	10986	35.59	37.39	14.90	14.71	14.71	14.71	14.71	487	
(0vX EL31)X(133 X 201Rf)	10564	9981	35.50	34.03	14.88	14.68	14.68	14.68	14.68	478	
LSD .05											
Logan	956	901	2.89	2.73	.65	.61	.68	.68	.68	64	
Farmington	1090	1028	3.07	2.89	.55	.52	.70	.70	.70	66	

Predictions on the basis of the average of the parental single crosses were made for three 4-way hybrids. Actual yields and sugar percentages were higher for some hybrids and lower for others than the single cross predicted gross sugar, tonnage, and sugar percentage. However, the difference at Logan for sugar percentage for hybrid (Ov X EL 31) X (133 X 201 Rf) was the only one that was significant.

Ranking these three 4-way hybrids on the basis of single-cross average vs actual performance differed for all variables at Logan and for gross sugar and tonnage at Farmington. At the latter location, sugar percentage and impurity index were ranked identical for single-cross averages vs actual performance.

Comparisons were made of the performance of 4-way hybrids having the same male parent and those having the same female parent (table 1-4). At Logan the three pollinators were similar in their average for gross sugar and tonnage, while at Farmington (CT9 X 129 Rf) and (133 X 201 Rf) were significantly better in gross sugar and tonnage than (CT9 X 201 Rf). The pollinator (133 X 201 Rf) had a significantly lower impurity index than (CT9 X 129 Rf) at Logan.

The variance table for combined locations indicates highly significant differences for locations and for varieties at each location (table 1-5). The location x variety interaction showed that the varieties did not have the same performance for gross sugar and tonnage at Farmington as they did at Logan.

#### TEST 2

##### Reciprocal crosses

Significant differences between single-cross hybrids and their reciprocals were noted in our 1970 experiments. This year we continued to test other reciprocal crosses for yield, sugar percent and quality factors.

Nine hybrids and reciprocals, along with two commercial varieties, were planted in paired plots at Logan in 1971. Two of the nine hybrids were evaluated in 1970. The test was repeated at Farmington, but due to insufficient quantity of seed, six of the entries were not grown at this location.

Poor seed germination and subsequent poor stand eliminated hybrid (CT9 X NB-1) from the test at both locations. In addition, (129 X A7111), (CT9 X A7111) and (Ovana X NB-1) had only about a 50 percent stand relative to other entries (tables 2-1 and 2-2, column 9).

At Logan entries coded 6, 8, and 17 were the only ones significantly superior to their reciprocals for gross sugar (table 2-1). These differences were no doubt due to the poor stand of the reciprocals. Tonnage was similar to gross sugar and also showed a close relationship with beet count.

Table 1-4. Average performance of pollinators over the same females and females over the same pollinators.

Description	Gross Sugar	Beets	Percent Sugar	Index
<b>Pollinators</b>				
<u>Logan:</u>				
CT9 X 201 Rf	7,041	22.26	15.82	399
CT9 X 129 Rf	7,081	22.47	15.76	431
133 X 201 Rf	7,086	22.09	16.06	365
<u>Farmington:</u>				
CT9 X 201 Rf	10,717	36.43	14.72	501
CT9 X 129 Rf	11,122	36.12	14.87	473
133 X 201 Rf	9,857	33.19	14.89	464
<b>Females</b>				
<u>Logan:</u>				
Ov CMS X EL31	7,430	23.46	15.84	425
AC CMS X NB-1	6,698	21.05	15.93	376
Ov CMS X NB-1	7,081	22.31	15.87	394
<u>Farmington:</u>				
Ov CMS X EL31	10,498	36.03	14.60	506
AC CMS X NB-1	10,706	34.71	14.89	471
Ov CMS X NB-1	10,492	35.01	15.00	461
<b>LSD .05</b>				
Logan	637	1.93	.43	45
Farmington	726	2.05	.37	46

Table 1-5. Performance prediction variety trial, combined locations, Farmington and Logan, Utah, 1971

Source of Variation	DF	Variance Table						Index	
		Gross Sugar			Tons Beets				
		Mean Square	F	Mean Square	F	Mean Square	F		
Locations	1	80.86 X 10 <sup>7</sup>	923.48**	11.08 X 10 <sup>3</sup>	1495.28**	47.19	157.30**	25.85 X 10 <sup>4</sup> 65.56*	
Blks/loc	8	47.34 X 10 <sup>5</sup>	44.14			4.16		43.65 X 10 <sup>3</sup>	
Varieties	27	24.06 X 10 <sup>5</sup>	2.75**	29.35	3.96**	0.60	2.00**	16.66 X 10 <sup>3</sup> 4.23*	
Loc X Var	27	15.68 X 10 <sup>4</sup>	1.79**	15.27	2.06**	0.34	NS	44.58 X 10 <sup>2</sup> NS	
Error	216	87.56 X 10 <sup>5</sup>		7.41		.30		39.43 X 10 <sup>2</sup>	
Total	279	40.96 X 10 <sup>5</sup>		51.04		0.61		72.74 X 10 <sup>2</sup>	
Locations	1	11.00 X 10 <sup>4</sup>	30.33**	23.10 X 10 <sup>4</sup>	181.18**	60.82	X 10 <sup>5</sup>	228.82** 64.61 X 10 <sup>2</sup> 142.06*	
Blks/loc	8	33.23 X 10 <sup>3</sup>		16.46 X 10 <sup>3</sup>		64.31	X 10 <sup>3</sup>	32.96	
Varieties	27	75.69 X 10 <sup>2</sup>	2.09**	71.14 X 10 <sup>2</sup>	5.58**	15.55	X 10 <sup>4</sup>	5.85** 433.96	
Loc X Var	27	43.56 X 10 <sup>2</sup>	NS	16.85 X 10 <sup>2</sup>	NS	28.75	X 10 <sup>3</sup>	NS 68.56	
Error	216	36.27 X 10 <sup>2</sup>		12.75 X 10 <sup>2</sup>		26.58	X 10 <sup>3</sup>	45.48	
Total	279	53.09 X 10 <sup>2</sup>		31.39 X 10 <sup>2</sup>		62.05	X 10 <sup>3</sup>	107.95	

\* Significant at 5% level  
\*\* Significant at 1% level

Table 2-1. Reciprocal single-cross variety test, Logan, Utah, 1971 (19 entries, 6 reps)

Code	Description	Acre Yield		Percent Sugar		Index		PPM		Beet Count
		Gross	Tons	Beets	Sugar	N	Na	K		
1	0v X 128	6,863	25.66	13.35	629	363	252	1,557	81	
2	128 X 0v	7,442	24.06	15.47	408	270	128	1,264	85	
3	CT9 X 133	7,131	23.65	15.07	535	348	218	1,526	59	
4	133 X CT9	7,543	25.66	14.68	507	327	184	1,408	75	
5	129 X A7111	3,522	12.49	14.11	655	355	237	1,934	20	
6	A7112 X 129	6,961	22.88	15.24	504	341	159	1,485	57	
7	CT9 X A7111	2,792	9.88	14.09	648	336	188	2,057	20	
8	A7112 X CT9	7,294	24.42	14.97	489	316	142	1,446	74	
10	NB-1 X CT9	7,625	26.18	14.60	506	349	172	1,318	72	
11	0v X CT9	7,306	25.33	14.43	522	295	156	1,613	74	
12	CT9 X 0v	7,990	27.42	14.58	579	394	164	1,569	82	
15	L-13 X 0v	6,411	21.37	14.98	517	347	152	1,496	57	
16	0v X L-13	7,586	26.32	14.42	561	339	218	1,575	76	
17	NB-1 X 0v	7,597	25.61	14.90	439	305	152	1,174	77	
18	0v X NB-1	6,106	21.23	14.38	689	424	211	1,956	39	
19	EL 31 X CT9	8,286	27.47	15.09	511	329	152	1,542	80	
20	CT9 X EL 31	7,560	25.72	14.72	648	416	219	1,833	65	
13	UI #7	7,385	24.81	14.90	540	359	171	1,532	78	
14	Tasco #3	7,573	24.70	15.34	413	253	108	1,374	89	
Mean of all varieties		6,893	23.41	14.70	542	340	178	1,561	66	
S.E. of mean		290.7	1.03	0.21	30.5	24.4	13.4	75.0	2.2	
L.S.D. (5% point)		818	2.90	0.60	86	69	38	211	6	
Calculated F		23.6**	20.34**	5.68**	7.18**	3.16**	8.30**	9.88**	8.03**	

\*\* Significant at 1% level

Table 2-2. Reciprocal single cross variety test, Farmington, Utah, 1971, (13 entries, 6 reps)

Code	Description	Acre Yield		Percent Sugar		PPM		Beet Count
		Gross Sugar	Tons Beets	Index	N	Na	K	
1	0v X 128	10,546	40.90	12.91	690	257	417	59
2	128 X 0v	12,140	41.25	14.70	462	247	211	69
3	CT9 X 133	10,433	37.82	13.80	630	290	319	52
4	133 X CT9	10,377	38.23	13.58	592	245	259	61
5	129 X A7111	4,181	15.13	13.70	575	195	306	21
6	A7112 X 129	9,497	31.71	15.00	482	252	205	49
7	CT9 X A7111	3,113	11.52	13.50	654	219	298	224
8	A7112 X CT9	10,696	37.18	14.39	570	260	267	61
10	NB-1XCT9	12,294	43.48	14.13	561	278	264	66
11	0v X CT9	11,742	42.44	13.83	599	241	274	67
12	CT9 X 0v	11,350	41.80	13.59	606	265	287	73
13	UI #7	9,416	33.88	13.90	579	300	302	72
14	Tasco #3	10,703	38.89	13.76	573	254	285	72
Mean all varieties		9,730	34.94	13.91	582	254	284	57
S.E. of Mean		39,449	1.38	0.19	37.66	23.61	23.0	2.65
L.S.D. (5% point)		1,116	3.90	0.54	107	NS	65	7
C.V. Percent		9.93	9.68	3.42	15.8	22.8	19.8	11.3
Calculated F		52.07**	54.35**	7.86**	2.65**	NS	5.18**	45.55**

\*\* Significant at 1% level

Hybrids with Ovana as a male parent appeared to have a higher sugar percentage than those with Ovana as a female parent.

Five hybrids, 2, 6, 8, 17, and 19, had a significantly lower impurity index than their counterpart hybrids. (Ovana X CT9) was significantly lower than its reciprocal cross for amino N, and (L-13 X Ovana) was significantly lower in sodium than the reciprocal single cross.

At the Farmington location, three entries, 2, 6 and 8, were significantly better than their reciprocal for gross sugar (table 2-2). However, the difference for entries 6 and 8 were mainly due to differences in stand. Crosses 2 and 6 significantly exceeded their counterpart crosses in sugar percent and single cross 2 had a lower index value. There were no differences in amino N at this location. Entry 6 had lower sodium content and 6 and 8 had lower potassium content than their reciprocals, but values for these crosses were non-significant. The performance of (CT9 X 133) was similar for both years 1970 and 1971.

Analysis of variance for four varieties and their reciprocals for combined locations showed highly significant differences for locations and varieties for each variable studied (table 2-3). However, the interaction of location by variety was significant only for gross sugar and sugar percent. (CT9 X 133) and (Ovana X CT9) were respectively higher than (133 X CT9) and (CT9 X Ovana) hybrids at Farmington, but just the opposite at Logan.

### TEST 3

#### Transplanting vs seeding

Transplanting vs seeded tests have been made at Logan the past few years in an effort to evaluate the merit of using transplants to extend the growing season. This year transplanting was accomplished with a tractor-mounted single-row tobacco transplanter. This machine not only made transplanting more rapid than previous hand methods, but also allowed uniform 12-inch spacing in the row, even placement of seedlings, and virtually little mortality of seedlings.

Transplants showed branched tap roots but were far less sprangled than had been noted in previous years. As expected, the 2-week old seedlings had less sprangling than the 4-week old seedlings.

The analysis of variance indicated that there was no difference in replications or varieties (table 3-1). Significant differences were observed between plantings for gross sugar, tonnage and beet count. The month-old transplants (Trans #1) produced the greatest yield and were significantly better than the seeded plots (table 3-2). The two-week old transplants (Trans #2) also had higher yield than the seeded plots, but the differences were non-significant.

The transplanted plots had higher impurities than the seeded plots and the older transplants exceeded the younger transplants in every case.

Table 2-3. Reciprocal single-cross variety test, combined locations, Farmington and Logan, Utah, 1971.

- C23 -

Source of Variation	DF	Gross Sugar			Tons. Beets			Percent Sugar			Index		
		Mean Square		F	Mean Square		F	Mean Square		F	Mean Square		F
		Mean	Square		Mean	Square		Mean	Square		Mean	Square	
Locations	1	28.31	$\times 10^2$	400.54**	48.66	$\times 10^2$	546.13**	22.43	140.19**	13.42	$\times 10^4$	18.42**	
Blks/Loc	10	17.50	$\times 10^5$	10.49	3.07**	0.60	11.12	$\times 10^3$	3.64	22.75**	$\times 10^3$	7.20**	
Varieties	7	25.05	$\times 10^5$	3.54**	27.36	NS	52.50	$\times 10^3$	0.46	2.88*	$\times 10^2$	NS	
Loc X Var	7	19.81	$\times 10^4$	2.80*	18.04	0.16	68.35	$\times 10^2$	0.16	72.88	$\times 10^2$		
Error	70	70.68	$\times 10^5$	8.91	62.97	0.72	12.33	$\times 10^3$					
Total	95	40.16	$\times 10^5$										

Source of Variation	DF	Amino N			Na			K			Beet Count		
		Mean Square		F	Mean Square		F	Mean Square		F	Mean Square		F
		Mean	Square		Mean	Square		Mean	Square		Mean	Square	
Locations	1	97.22	$\times 10^3$	25.13**	35.48	$\times 10^4$	156.02**	20.61	$\times 10^5$	61.35**	35.28	$\times 10^2$	93.80**
Blks/Loc	10	70.24	$\times 10^3$	24.82	2.03	13.45	$\times 10^4$	13.45	$\times 10^4$	46.26			
Varieties	7	11.95	$\times 10^3$	3.09**	30.05	$\times 10^2$	13.21**	23.54	$\times 10^4$	7.00**	719.64	19.13**	
Loc X Var	7	47.71	$\times 10^2$	NS	41.21	$\times 10^2$	NS	61.87	$\times 10^3$	NS	122.59	3.26**	
Error	70	38.68	$\times 10^2$	22.74	81.90	$\times 10^2$	33.59	$\times 10^3$	82.51	$\times 10^3$	37.61		
Total	95	58.45	$\times 10^2$										

\* Significant at 5% level

\*\* Significant at 1% level

Table 3-1. Transplant vs seeding variety trial, Logan, Utah, 1971 (4 entries, 4 reps)

Code	Description	Trans #1	Trans #2	Seed	Mean	Trans #1	Trans #2	Seed	Mean
301	Amal. Hybrid #1	109	144	128	127	1,452	1,312	1,402	1,389
302	Amal. Hybrid #3	157	159	126	147	1,448	1,456	1,456	1,453
303	UI Hybrid B	159	150	123	144	1,417	1,376	1,357	1,380
304	UI Hybrid D	157	112	111	126	1,297	1,385	1,247	1,310
Mean all varieties		145	141	122	136	1,403	1,382	1,363	1,383
LSD (5% point):			30			NS	NS	NS	NS
Seed and transplants									
Varieties									

Table 3-2 Transplant vs seeding variety trial, Logan, Utah, 1971 (4 entries, 4 reps)

Variance Table										
Gross Sugar					Tons Beets					
DF	Mean		Mean		Mean		Sugar %		Index	
	Mean	Sq	F	Sq	F	Sq	F	Sq		
Replications	3	56.85	X	10 <sup>4</sup>	NS	12.65	NS	.6475	NS	23.88
Varieties	3	20.44	X	10 <sup>5</sup>	NS	12.59	NS	.5331	NS	23.40
Error A	9	56.73	X	10 <sup>4</sup>	5.23	.2636		64.74	X	10 <sup>2</sup>
Between Plantings	2	41.63	X	10 <sup>5</sup>	10.67**	41.45	12.95**	.0247	NS	34.04
Var X Plantings	6	29.17	X	10 <sup>4</sup>	NS	2.36	NS	.0981	NS	10.24
Error B	24	39.03	X	10 <sup>4</sup>	3.20	6.31		.1169	X	10 <sup>2</sup>
Total	47	68.91	X	10				.1991		50.76
										X
										10 <sup>2</sup>
Na					K					Beet Count
Replications	3	34.57	X	10 <sup>3</sup>	NS	1530.47	NS	1598.52		8.24
Varieties	3	13.87	X	10 <sup>3</sup>	NS	1428.69	NS	14122.02	NS	49.63
Error A	9	10.49	X	10 <sup>2</sup>	NS	1149.90		26267.22		16.91
Between Plantings	2	39.81	X	10 <sup>2</sup>	NS	2514.02	5.88**	6585.06	NS	124.52
Var X Plantings	6	28.74	X	10 <sup>2</sup>	NS	1414.96	NS	12736.90	1.73	26.05
Error B	24	62.33	X	10 <sup>2</sup>				7341.97		19.06
Total	47	88.20	X	10 <sup>2</sup>				915.19		25.29

\*\* Significant at 1% level

Seeded plots had significantly more beets per plot, on the average, than did the transplants. Thus, yield differences cannot be attributed to differences of stand.

#### TEST 4

##### Genotype Times Nitrogen Interaction

D. L. Doney, R. E. Wyse, and J. C. Theurer

This test was set up as a pilot test to study the effect of fertility on different genotypes. Four hybrids (genotypes) with one parent in common, but varying in yield and sugar potential, plus a commercial check (UI Hybrid B) were selected for this test. The potential of the four hybrids were as follows:

Ov CMS X 0198S = high yield, medium to low sugar

Ov CMS X L-19 = low yield, high sugar

Ov CMS X 0461 = low yield, medium sugar, and

Ov CMS X CT9 = high yield, low sugar

The five hybrids (genotypes) were planted in a split-plot design with fertility levels as whole plots. The fertility levels were (1) zero nitrogen, (2) 120 lbs N (broadcast prior to planting), and (3) 240 lbs N (1/2 broadcast prior to planting and 1/2 sidedressed July 14). The trial was harvested and root weights taken October 14. Two 10-beet samples were taken from each plot and analyzed for percent sugar, Stanek-Pavlas nitrogen, sodium, potassium, clear juice purity, and total amino acids. These data were used to calculate gross sugar, impurity index, recoverable white sugar per ton (RWST), recoverable white sugar per acre (RWSA), and mg amino acids per kg fresh weight.

The F tests for the fertility, genotype and fertility times genotype lines in the ANOV for each of the above mentioned factors are given in table 4-1. There were significant differences between fertility levels and genotypes for all factors (tables 4-1 and 4-2).

A significant fertility times genotype interaction indicates that genotypes react differently to increasing levels of fertility. Since these genotypes have different production potentials, we expected some significant interactions. The only significant fertility times genotypic interactions were for sodium, percent clear juice purity and mg amino acids per kg fresh weight (table 4-1). Sodium fluctuated so greatly that no clear pattern could be observed. The interaction observed for percent clear juice purity and amino acids was very similar, i.e. genotype Ov CMS X 0198 S was affected the most, whereas genotype UI Hybrid B was most tolerant to increasing levels of N for both factors (tables 4-3 and 4-4). Genotype Ov CMS X 0198 S decreased in percent clear juice purity from 95.2 at 0 N to 92.3 at 240 lbs N while genotype

Table 4-1. F tests for the fertility, genotype and fertility times genotype lines in the ANOV for all measured and calculated factors.

Gross Sugar Lbs/A	Root Weight Tons/A	% Sugar	Index	N (ppm)	Na (ppm)	K (ppm)	RWS/T 1bs	RWS/A 1bs	Clear Juice Purity %	mg aa/ Kg fresh wt
Fertility	30.04 <sup>b</sup>	55.30 <sup>b</sup>	4.54 <sup>a</sup>	53.79 <sup>b</sup>	44.53 <sup>b</sup>	12.98 <sup>b</sup>	3.23 <sup>a</sup>	10.8 <sup>b</sup>	20.31 <sup>b</sup>	50.6 <sup>b</sup>
Genotype	16.50 <sup>b</sup>	36.88 <sup>b</sup>	68.36 <sup>b</sup>	11.78 <sup>b</sup>	11.90 <sup>b</sup>	14.56 <sup>b</sup>	10.43 <sup>b</sup>	58.64 <sup>b</sup>	14.67 <sup>b</sup>	24.0 <sup>b</sup>
Fert X geno	1.36	1.90	<1.00	<1.00	1.09	2.68 <sup>a</sup>	<1.00	1.17	1.29	3.25 <sup>b</sup>
										4.24 <sup>b</sup>

a = Significant at  $p = .05$   
b = Significant at  $p = .01$

Table 4-2. Means of each genotype and the three nitrogen levels for all the measured and calculated factors.

Gross Sugar Lbs/A	Root Weight Tons/A	% Sugar	Index	N (ppm)	Na (ppm)	K (ppm)	RWS/T 1bs	RWS/A 1bs	Clear Juice Purity %	mg aa/ Kg fresh wt
Genotypes										
Ov CMS X 0198S	7,922	26.24	15.12	665	501	101	1,852	281.2	7,355	93.9
Ov CMS X L-19	7,406	22.68	16.36	501	348	99	1,737	309.4	6,989	95.0
Ov CMS X 0461	6,674	21.27	15.71	556	462	104	1,483	296.9	6,303	94.7
UI Hybrid B	7,627	24.66	15.46	490	345	105	1,493	295.9	7,283	95.5
Ov CMS X CT9A	7,576	26.38	14.39	615	365	148	1,856	270.1	7,093	94.5
LSD .05	326	1.04	0.25	61	59	15	162	5.6	309	0.3
Fertility level										
0 N	6,596	21.29	15.54	470	287	92	1,633	298.6	6,340	95.6
120 lbs N	7,949	25.28	15.77	518	361	104	1,659	298.6	7,515	95.0
240 lbs N	7,777	26.16	14.92	709	565	139	1,759	274.9	7,558	93.6
LSD .05	423	1.10	0.64	54	68	21	117	13.1	421	.5

Table 4-3. Genotype times fertility interaction for percent clear juice purity.

Genotype	Lbs nitrogen per acre		
	0	120	240
Ov CMS X 0198 S	95.2	94.2	92.3
Ov CMS X L-19	95.8	95.3	93.9
Ov CMS X 0461	95.5	95.2	93.5
UI Hybrid B	96.0	95.6	94.8
Ov CMS X CT9A	95.5	94.7	93.4

Table 4-4. Genotype times fertility interaction for mg amino acids per kg fresh weight.

Genotype	Lbs nitrogen per acre		
	0	120	240
Ov CMS X 0198 S	2,620	4,313	6,184
Ov CMS X L-19	1,819	2,677	4,468
Ov CMS X 0461	2,940	3,243	5,399
UI Hybrid B	2,023	2,700	3,503
Ov CMS X CT9A	1,978	3,029	4,542

UI hybrid B decreased in percent clear juice purity from 96.0 at 0 N to 94.8 at 240 lbs (table 4-3). For amino acids, genotype Ov CMS X 0198S increased from 2620 at 0 N to 6184 at 240 lbs N, whereas genotype UI hybrid B increased from 2023 at 0 N to 3503 at 240 lbs N (table 4-4).

The fertility times genotype for root weight was large but not quite significant at  $p = .05$  (table 4-1). For root weight, all genotypes increased significantly from 0 N to 120 lbs N, but only one genotype (Ov CMS X CT9A) responded significantly to the 240 lbs N level. A significant increase in root yield at the 240 lbs N level over the 120 lbs N level was observed for this genotype.

The comparisons of the effects of fertility summed over all genotypes (table 4-2) showed an increase in root yield with increased N, but a decrease in percent sugar and most quality factors with increased levels of N.

High-yield, low-sugar genotypes were generally poor in quality, while low-yield, high-sugar genotypes were generally high in quality (table 4-2). Those genotypes that varied significantly in their tolerance to increasing levels of N were expected to be the high and low sugar types, but this was not the case (table 4-2).

These data suggest that genotypes can be selected that are relatively tolerant to high N levels.

Note: The percent sugar in the clear juice and the percent soluble solids in the clear juice determinations were provided by M. G. Frakes, Michigan Sugar Company.

## TEST 5

### Genotypic Competition

This test was set up as a pilot study to determine if different genotypes react differently for percent sugar, yield and quality factors under competitive stress.

Four genotypes (entries) were selected. One genotype (Ov CMS X 0198S) is a high-yield, low-sugar type, while Ov CMS X L-19 is a low-yield, high-sugar type. The other two entries are commercial hybrids. These four entries were planted at 3 different plant populations (46,000, 34,500, and 23,000 plants per acre).

A significant population x entry interaction would indicate that the different genotypes react differently to competition. The only factor that gave a significant interaction was sodium (table 5-1), which failed to show an observable trend. Therefore, these genotypes which

Table 5-1. F tests for plant populations, entries and populations times entries lines in the ANOV for all measured characters.

Line in ANOV	Gross sugar Lbs/acre	Root wt. Tons/acre	% Sugar	Index	Nitrogen (ppm)	Sodium (ppm)	Potassium (ppm)
Populations	1.17	1.95	1.18	7.63*	4.28*	1.57	5.85*
Entries	2.71	16.22**	39.37**	92.60**	49.35**	9.80**	47.19**
Pop'n X Entries	<1.00	<1.00	<1.00	1.72	<1.00	2.70*	1.54

\* Significant differences at  $p = .05$

\*\* Significant differences at  $p = .01$

Table 5-2. Means of each entry and each plant population for gross sugar, root weight, percent sugar, index, nitrogen, sodium and potassium.

Entries	Gross sugar Lbs/acre	Root wt Tons/acre	% Sugar	Index	Nitrogen (ppm)	Sodium (ppm)	Potassium (ppm)
Ov CMS X 0198S	7,798	26.64	14.64	670	465	135	1,869
Ov CMS X L19	7,615	23.52	16.19	467	297	118	1,673
UI Hybrid B	7,486	24.79	15.10	472	285	146	1,463
Tasco Hybrid #1	7,403	24.13	15.34	421	249	109	1,437
LSD .05	295	0.95	0.29	33	39	15	84
Plant pop'n per acre							
46,000	7,391	24.23	15.28	475	298	118	1,524
34,500	7,652	24.83	15.43	501	326	131	1,591
23,000	7,683	25.24	15.25	547	348	133	1,716
LSD .05	467	1.02	0.25	42	39	21	127

differ in yielding ability and percent sugar react similarly at varying levels of competition. There were differences between entries for all factors except gross sugar (tables 5-1 and 5-2). The low-sugar genotype was high for the quality factors (index, nitrogen, sodium and potassium) whereas, the high-sugar genotype was low for these factors (table 5-2).

As the competition decreased, (decrease in plant population) the quality factors (index, nitrogen, sodium and potassium) increased even though there was no significant change in gross sugar, root weight or percent sugar (table 5-2).

## TEST 6

### Evaluation of double-cross hybrids

J. C. Theurer, G. K. Ryser, and D. L. Doney

Test 6 was an evaluation of 25 pollen-restored double-cross hybrids planted at both Logan and Farmington.

At Logan (NB-1 X L 53) X (EL 31 X 129 Rf) was the hybrid having the highest gross sugar (table 6-1). The check variety, UI Hybrid D, yielded only three pounds less than this entry. Six of the seven highest yielding hybrids had Ovana or L-53 (an Ovana derivative) as a parent. (EL 31 X 129 Rf) and (Ov.2 X 129Rf) were the pollinators of the five hybrids yielding the most gross sugar. Specific combining ability was evident, however, because these pollinators were also parents of hybrids that yielded below the mean. (A7113 X EL 31) X (Ov.2 X 129 Rf) had a sugar percentage of 15.84, the highest in the test. With the exception of (28.02 X CT7) X (Ov.2 X 129 Rf) and (29.505 X CT7) X (EL 31 X 129 Rf) entries having high-sugar percentage were also those than had high gross sugar. UI Hybrid E and (28.02 X CT7) X (Ov.2 X 129 Rf) had the lowest impurity index. Tasco hybrid #3 had the lowest amino N content of all of the entries, but differences with 12 other entries were non-significant.

Hybrid (129 X L-19) X (Ov.2 X 129 Rf) and (A7113 X EL 31) X (Ov.2 X 129 Rf) were highest in gross sugar at Farmington (table 6-2). They were significantly superior for this character to all but nine hybrids and two commercial varieties, and 12 hybrids and two commercial varieties, respectively. Every entry exceeded US 22/3 for yield. (29.505 X CT7) X (EL 31 X 129 Rf) had a sugar percentage of 15.11 but this was not significantly different than 13.65, the sugar percentage for (Ov X 129) X (EL 31 X 129 Rf), the lowest in the test. Hybrids with the lowest (code 16) and the highest (code 5) impurity indices were among the low-yielding entries. Indices for high-yielding entries were not significantly different from the mean index value. Tasco #3 commercial hybrid was the lowest in amino N at this location also.

Table 6-1 Evaluation of double-cross restorer hybrids, Logan, Utah, 1971 (31 entries, 6 reps)

Code	Description	Acre Yield			PPM			Beet Count
		Gross Sugar	Tons Beets	Percent Sugar	Index	Amino N	K	
14	(NB-1 X L-53) X (EL31 X 129 Rf)	7,731	24.53	15.75	451	336	142	1,298 79
27	UI Hybrid D	7,728	24.70	15.63	470	390	124	1,205 81
25	(129 X L-19) X (0v.2 X 129 Rf)	7,691	25.17	15.28	415	235	176	1,349 86
23	(A7113 X EL31) X (0v.2 X 129 Rf)	7,596	23.98	15.84	459	328	135	1,401 83
19	(UI Hybrid B) X (0v.2 X 129 Rf)	7,542	23.96	15.72	453	341	121	1,306 82
4	(A7113 X 133) X (EL31 X 129 Rf)	7,509	23.87	15.70	453	330	148	1,315 83
17	(0v X NB-1) X (S33 X 201 Rf)	7,491	24.56	15.13	431	292	160	1,213 86
18	(NB-1 X L-53) X (do)	7,485	24.78	15.09	455	309	193	1,244 76
7	(UI Hybrid B) X (0v X 201 Rf)	7,463	25.39	14.71	516	324	206	1,451 82
28	UI Hybrid E	7,448	23.93	15.56	371	231	138	1,185 83
6	(28.02 X CT7) X (EL31 X 129 Rf)	7,393	24.31	15.18	432	299	152	1,210 86
3	(UI SPCA X NB-1) X (do)	7,211	23.46	15.38	446	292	130	1,388 84
8	(UI SPCA X CT5) X (0v X 201 Rf)	7,169	24.81	14.43	459	230	162	1,502 86
22	(28.02 X CT7) X (0v.2 X 129 Rf)	7,127	22.58	15.78	379	256	112	1,214 82
9	(29.505 X CT7) X (0v X 201 Rf)	7,120	24.08	14.78	497	347	140	1,347 85
26	UI Hybrid B	7,061	23.05	15.33	477	324	174	1,377 77
20	(UI SPCA X CT5) X (0v.2 X 129 Rf)	7,046	23.29	15.11	459	319	132	1,314 86
10	(F.C. 601 X L-36) X (0v X 201 Rf)	7,047	23.76	14.83	418	235	163	1,309 82
31	US 22/3	7,017	22.91	15.33	469	295	143	1,485 83
12	(29.505 X CT7) X (EL31 X 129 Rf)	6,992	22.28	15.77	426	306	100	1,328 85
13	(0v X NB-1) X (do)	6,861	23.13	14.82	546	375	175	1,476 85
2	(28.02 X CT7) X (0v X 129 Rf)	6,845	22.06	15.54	402	258	109	1,311 81
21	(29.505 X CT7) X (0v.2 X 129 Rf)	6,841	22.22	15.40	440	317	123	1,266 82
5	(0v X 129) X (EL31 X 129 Rf)	6,836	22.91	14.95	503	328	179	1,440 84
11	(UI SPCA X CT5) X (EL31 X 129 Rf)	6,811	22.19	15.34	421	277	122	1,304 88

Table 6-1. (continued)

Code	Description	Acre Yield		Percent Sugar	Index	PPM			Beet Count
		Gross Sugar	Tons Beets			Amino N	Na	K	
30	Tasco Hybrid #3 (UI SPCA X NB-1) X (0v X 129RF)	6,750	22.39	15.06	404	227	144	1,325	86
1	(F.C. 601 X L-36) X (0v.2 X 129RF)	6,734	22.17	15.18	468	318	159	1,339	85
24	Tasco Hybrid #1 (29.505 X CT7) X (S33 X 201 RF)	6,727	22.58	14.89	444	290	146	1,279	71
29	(UI SPCA X CT5) X (S33 X 201 RF)	6,710	21.89	15.33	416	273	115	1,303	81
16	Mean of all varieties	7,123	23.34	15.26	448	300	14.5	1,320	83
216.15	S.E. of mean	216.15	0.65	0.17	23.43	24.41	10.15	55.59	1.83
605	L.S.D. (5% point)	605	1.82	.48	66	68	28	156	5
7.43	C.V. Percent	7.43	6.85	2.77	12.83	19.90	17.17	10.31	5.42
3.03**	Calculated F	3.05**	4.63**	2.61**	2.97**	2.61**	2.50**	3.53**	3.53**

\*\* Significant at 1% level

Table 6-2. Evaluation of double-cross restorer hybrids, Farmington, Utah, 1971 (31 entries, 6 reps)

Code	Description	Acre Yield			PPM			Beet Count
		Gross Sugar	Tons Beets	Percent Sugar	Index	N	K	
25	(129 X L-19) X (0v.2 X 129 Rf) (A7113 X EL 31) X (" "	11,609	40.54	14.33	552	246	297	1,764
23	11,465	38.28	14.99	508	278	197	1,645	77
06	11,405	38.28	14.90	457	252	194	1,439	73
08	11,242	40.02	14.04	529	225	254	1,710	76
18	11,219	39.08	14.35	477	234	293	1,394	82
28	UI Hybrid E (0v X NB-1) X (S33 X 201 Rf) (28.02 X CT7) X (0v X 129 Rf) (F.C. 601 X L-36) X (0v.2 X 129 Rf)	11,107	38.39	14.45	489	255	214	1,494
17	11,036	39.60	13.94	547	273	283	1,558	73
02	10,975	37.24	14.73	478	246	178	1,574	69
24	10,864	36.88	14.73	490	249	188	1,628	76
27	UI Hybrid D 10,805	36.41	14.84	475	312	163	1,339	71
09	(29.505 X CT7) X (0v X 201 Rf) (UI SPCA X CT5) X (EL 31 X 129 Rf) (" X NB-1) X (" ") (28.02 X CT7) X (0v.2 X 129 Rf)	10,761	38.01	14.18	554	253	252	1,757
11	10,708	35.81	14.95	442	223	149	1,530	77
03	10,649	37.07	14.38	510	265	195	1,562	80
22	10,604	38.17	13.92	443	224	148	1,384	77
14	10,595	36.74	14.43	532	286	235	1,593	79
01	(UI SPCA X NB-1) X (0v X 129 Rf) (UI Hybrid B) X (0v X 201 Rf) (F.C. 601 X L-36) X (" ") (UI SPCA X CT5) X (0v.2 X 129 Rf)	10,569	36.11	14.68	521	280	187	1,662
07	10,548	37.73	14.01	622	316	301	1,772	74
10	10,518	37.57	14.07	534	226	249	1,713	79
20	10,504	35.81	14.68	483	245	179	1,603	70
21	10,492	35.45	14.79	489	268	184	1,545	70
30	Tasco Hybrid #3 " "#	10,392	37.38	13.91	554	270	228	1,684
29	10,343	36.08	14.34	464	218	205	1,492	83
15	(UI SPCA X CT5) X (S33 X 201 Rf) (A7113 X 133) X (EL 31 X 129 Rf)	10,358	36.00	14.41	484	258	197	77
04	10,307	35.72	14.45	594	346	233	1,700	74
12	10,226	33.91	15.11	462	282	123	1,484	78

Table 6-2. (continued)

Code	Description	Acre Yield			PPM			Beet Count
		Gross Sugar	Tons Beets	Percent Sugar	Index	N	Na	
13	(0v X NB-1) X (EL 31 X 129 Rf)	10,189	36.00	14.21	542	300	217	1,532
16	(29.505 X CT7) X (S33 X 201 Rf)	10,178	34.54	14.74	413	228	230	1,199
19	(U1 Hybrid B) X (0v.2 X 129 Rf)	9,934	33.86	14.67	457	246	171	1,465
26	U1 Hybrid B	9,755	34.32	14.24	543	283	261	1,586
05	(0v X 129) X (EL 31 X 129 Rf)	9,706	35.64	13.65	676	316	326	1,956
31	US 22/3	9,437	32.54	14.52	533	259	240	1,718
	Mean of all varieties	10,597	36.75	14.44	511	263	218	1,579
	S.E. of mean	330.16	0.92	.31	31.79	22.91	23.81	79.69
	L.S.D. (5% point)	924	2.56	NS	89	64	67	223
	C.V. Percent	7.63	6.10	5.34	15.23	21.33	26.71	12.36
	Calculated F	2.46**	4.16**	NS	3.06**	1.91**	4.30**	3.63**

Table 6-3. Combined data for experiment 6.

Source of Variation	DF	Gross Sugar				Tons Beets				Percent Sugar				Mean Square	F	Mean Square	F	Mean Square	F	Mean Square	F	Index										
		Mean Square		F		Mean Square		F		Mean Square		F																				
		Mean	Square			Mean	Square			Mean	Square																					
Locations	1	11.22	X	10 <sup>8</sup>	2401.54**	16.71	X	10 <sup>3</sup>	4397.37**	61.90		158.72**		37.84	X	10 <sup>4</sup>	80.87**															
Blks/Loc	10	30.94	X	10 <sup>5</sup>	44.34					2.86				42.46	X	10 <sup>3</sup>																
Varieties	30	17.34	X	10 <sup>4</sup>	3.71**	21.74			5.72**	1.22		3.13**		20.13	X	10 <sup>3</sup>	4.30**															
Loc X Var	30	72.01	X	10 <sup>4</sup>	1.54*	7.02			1.85**	0.41		NS		70.05	X	10 <sup>2</sup>	1.50*															
Error	300	46.72	X	10 <sup>5</sup>		3.80				0.39				46.79	X	10 <sup>2</sup>																
Total	371	36.84	X	10 <sup>5</sup>		51.64				0.69				81.43	X	10 <sup>2</sup>																
Variance Table																																
Source of Variation	DF	Mean Square				Mean Square				Mean Square				Mean Square				Mean Square				Beet Count										
Locations	1	13.00	X	10 <sup>4</sup>	38.67**	50.23	X	10 <sup>3</sup>	249.90**	62.05	X	10 <sup>4</sup>	219.10**	65.16	X	10 <sup>2</sup>	151.43**															
Blks/Loc	10	28.14	X	10 <sup>3</sup>		16.89	X	10 <sup>3</sup>		18.63	X	10 <sup>4</sup>		131.48																		
Varieties	30	12.97	X	10 <sup>2</sup>	3.86**	15.43	X	10 <sup>2</sup>	7.68**	14.75	X	10 <sup>3</sup>	5.21**	127.50			2.96*															
Loc X Var	30	36.72	X	10 <sup>2</sup>		30.24	X	10 <sup>2</sup>		1.50*				37.10	X	10 <sup>3</sup>	NS	47.79					NS									
Error	300	33.62	X	10 <sup>2</sup>		20.10	X	10 <sup>2</sup>						28.32	X	10 <sup>3</sup>		43.03														
Total	371	51.74	X	10 <sup>2</sup>		49.27	X	10 <sup>2</sup>						59.57	X	10 <sup>2</sup>		70.08														
N																																
Source of Variation	DF	Mean Square				Mean Square				Mean Square				Mean Square				Mean Square				K										
Locations	1	13.00	X	10 <sup>3</sup>	38.67**	50.23	X	10 <sup>3</sup>	249.90**	62.05	X	10 <sup>4</sup>	219.10**	65.16	X	10 <sup>2</sup>	151.43**															
Blks/Loc	10	28.14	X	10 <sup>3</sup>		16.89	X	10 <sup>3</sup>		18.63	X	10 <sup>4</sup>		131.48																		
Varieties	30	12.97	X	10 <sup>2</sup>	3.86**	15.43	X	10 <sup>2</sup>	7.68**	14.75	X	10 <sup>3</sup>	5.21**	127.50			2.96*															
Loc X Var	30	36.72	X	10 <sup>2</sup>		30.24	X	10 <sup>2</sup>		1.50*				37.10	X	10 <sup>3</sup>	NS	47.79					NS									
Error	300	33.62	X	10 <sup>2</sup>		20.10	X	10 <sup>2</sup>						28.32	X	10 <sup>3</sup>		43.03														
Total	371	51.74	X	10 <sup>2</sup>		49.27	X	10 <sup>2</sup>						59.57	X	10 <sup>2</sup>		70.08														

\* Significant at 5% level  
\*\* Significant at 1% level

Analysis of variance for combined data indicated highly significant F values for locations and varieties for all variables (table 6-3). The interaction of varieties x locations was also significant for yield, impurity index, and potassium content, indicating that the entries did not show identical performance at the two locations. On the average, yields at Farmington were greater, sugar percentage was lower, and index, ppm sodium, and ppm potassium were higher than observed at Logan.

### TEST 7

#### Evaluation of New Pollinator Inbreds

This test was to evaluate the potential yield and sugar percentage of new  $S_2$  and  $S_3$  inbreds. Data are listed in table 7-1 in order of gross sugar.

None of the new hybrids had superior yield when compared to the highest yielding commercial variety. Five hybrids were significantly lower in yield than the lowest yielding check.

Specific combining ability for yield, sugar percent and quality was evident. Inbreds 75106, 75123, 29.008 and 27.53 were parents of the high-tonnage varieties. Inbreds 0464, 29.002, 22.005, 29.005 and GB curly-top selections showed little promise as useful pollinators.

UI Hybrid D had the highest sugar percentage in this test. Pollinator inbreds that showed the best performance for this character were 75123, 27.53 and 28.19. These same inbreds also had the best quality as was evident by their low impurity index values. GB-2 curly top selection, 75106, 29.005 and 22.005 were components of hybrids of lowest quality.

### TEST 8

#### Inbred Lines

This test compares the yield, sugar percentage and impurity factors of more recently released inbreds with other inbreds which have been utilized in hybrids at Logan.

There was a large amount of variation for every variable that was measured (table 8-1). Eight inbreds were significantly higher in yield than the mean of the test. SLC 129 was significantly the highest yielding inbred and SLC 133 was lowest. However, since SLC 133 had such a poor stand, this evaluation was not a valid test of performance of this inbred.

As expected, L-19 was far superior to other entries for sugar percentage. CT8, 28.19, AI-10 and 0461 S (282) were also significantly higher than the test mean for this variable. SLC 132, F.C. 601, L-13, and SLC 133 were low in sugar percentage.

Table 7-1. Evaluation of new pollinator inbreds, Logan, Utah, 1971 (41 entries, 5 reps)

Code	Description	Acre Yield			Percent Sugar	Index	PPM			Beet Count
		Gross Sugar	Tons Beets	Beets			N	Na	K	
711	(S33 X NB1) X 75106	8,183	26.07	15.70	516	413	120	1,415	83	
728	(S33 X NB1) X 75123	8,137	25.41	16.01	389	236	160	1,315	84	
725	7114 X 75123	7,739	24.59	15.74	384	226	136	1,321	85	
705	(133 CMS X NB1) X (29.008)	7,686	25.38	15.14	463	345	166	1,186	73	
733	(S33 X NB1) X 27.53	7,527	24.59	15.31	396	271	126	1,168	74	
738	U1 Hybrid E	7,469	24.46	15.25	418	265	157	1,257	81	
737	U1 Hybrid D	7,442	23.70	16.13	389	315	103	1,095	82	
712	(F.C. 601 X CT5) X 75106	7,435	23.99	15.49	516	407	111	1,407	80	
735	(133 X F.C. 601) X 27.53	7,368	23.07	15.98	400	271	144	1,272	64	
727	0v CMS X 75123	7,338	23.99	15.28	499	263	195	1,716	79	
736	U1 Hybrid B	7,333	23.89	15.36	458	315	137	1,358	76	
703	(0v CMS X EL31) X 29.008	7,280	24.49	14.88	499	369	160	1,266	70	
723	(0v 1 X CT5B) X 75123	7,245	23.96	15.13	458	258	177	1,488	84	
724	(0v 1 X 9540) X "	7,224	24.92	14.51	548	304	198	1,689	84	
740	Tasco Hybrid #3	7,224	23.60	15.30	446	292	139	1,360	84	
709	(133 X CT5) X 28.19	7,201	22.67	15.89	391	276	111	1,225	78	
726	129 CMS X 75123	7,184	23.66	15.21	450	248	149	1,529	73	
730	133 CMS X C-CTR Selection	7,160	23.73	15.08	497	358	123	1,384	74	
734	0v CMS X 27.53	7,093	22.21	15.97	436	348	114	1,219	70	
702	(7113 X 133) X 29.008	7,035	23.93	14.64	492	357	187	1,193	72	
710	CT9 CMS X 75106	7,006	23.10	15.15	618	507	121	1,543	68	
704	(0v CMS X A7111) X 29.008	6,993	23.17	15.09	501	384	178	1,228	82	
713	133 CMS X GB-2 Selection	6,934	23.07	15.06	502	350	234	1,285	69	
716	(S33 X NB1) X 0464	6,824	22.34	15.27	434	309	128	1,235	79	
708	0v CMS X 28.19	6,811	22.11	15.41	473	330	156	1,353	80	

Table 7-1. (continued)

Code	Description	Acre Yield			Percent			PPM			Beet Count
		Gross Sugar	Tons Beets	Percent Sugar	Index	N	Na	K			
741	US 22/2	6,784	21.49	15.79	404	256	137	1,328	80		
739	Tasco Hybrid #1 (UI SPCA X NBT)	6,773	22.24	15.21	431	310	106	1,222	79		
701	X 29.008	6,748	21.82	15.47	420	258	145	1,364	75		
706	0v CMS X 29.002	6,723	22.64	14.90	409	253	139	1,217	69		
720	0v CMS X 22.005	6,594	22.04	14.95	517	332	199	1,464	73		
721	133 CMS X 22.005	6,566	21.55	15.20	496	354	159	1,373	63		
719	0v CMS X 29.005	6,551	23.30	14.03	645	394	198	1,744	62		
722	(S33 X NBT) X 22.005	6,538	21.48	15.21	444	261	157	1,439	80		
717	(S33 X CT5) X 0464	6,515	21.45	15.19	459	324	124	1,321	88		
729	129 CMS X C-CTR Selection	6,485	21.19	15.28	438	295	124	1,326	76		
718	7114 X 29.005	6,085	20.10	15.16	476	331	174	1,313	63		
715	0v CMS X 0464	5,871	19.31	15.22	509	379	162	1,339	78		
707	133 CMS X 29.002	5,489	17.63	15.60	486	397	129	1,258	45		
732	133 CMS X GB-6 Selection	5,302	17.23	15.40	503	356	207	1,380	34		
731	129 CMS X "	5,210	16.83	15.41	411	238	143	1,374	33		
714	129 CMS X GB-2 Selection	4,320	14.19	15.18	531	343	240	1,522	28		
Mean of all varieties		6,864	22.45	15.30	467	320	153	1,353	72		
S.E. of Mean		272.8	0.81	0.24	28	28.7	16.70	62.9	2.51		
LSD (5% point)		764	2.28	0.68	79	81	4.7	176	7		
C.V. Percent		8.89	8.11	3.55	13.42	20.11	24.42	10.39	7.81		
Calculated F		7.99**	9.25**	2.84**	4.38**	4.34**	4.13**	5.30**	3.16**		

\*\* Significant at 1% level

Table 8-1. Inbred variety test, Logan, Utah, 1971 (40 entries, 3 reps)

Code	Description	Acre Yield		Percent Sugar		Index		PPM		Beet Count
		Gross	Tons Beets	Sugar	Percent Sugar	N	Na	K		
805	SLC 129	9,127	29.37	15.53	419	265	99	1,409	88	
832	A7534	7,515	26.07	14.40	537	242	173	1,881	81	
840	0v #2	7,143	23.87	14.95	427	236	129	1,429	86	
810	L-19	6,913	18.76	18.42	391	300	111	1,529	74	
834	129 CMS	6,690	23.05	14.52	432	221	140	1,430	82	
821	0198S (323)	6,538	21.29	15.37	713	580	109	1,912	81	
816	28.19	6,530	19.97	16.37	409	254	128	1,474	67	
839	AI-12 CMS	6,462	21.67	14.90	598	312	135	2,131	85	
836	506 CMS	6,095	20.08	15.18	490	302	134	1,581	72	
818	29.005	6,052	19.75	15.25	526	299	167	1,768	69	
806	SLC 132	6,025	21.95	13.72	620	385	309	1,415	77	
829	AI-1	6,014	20.68	14.53	515	350	120	1,431	65	
802	CT8	5,949	18.26	16.27	467	336	75	1,588	68	
814	0464	5,871	19.91	14.77	586	394	169	1,645	76	
823	NB-1	5,763	19.64	14.63	427	239	117	1,392	86	
813	0v.1	5,752	19.31	14.93	492	349	115	1,249	76	
833	A7535	5,713	18.54	15.42	489	304	140	1,606	71	
804	CT9A	5,631	17.88	15.75	429	303	143	1,291	72	
835	NB-1 CMS	5,551	19.03	14.57	448	256	114	1,423	67	
812	L-36	5,452	18.76	14.55	408	249	106	1,233	76	
827	F.C. 506	5,450	18.04	15.10	491	273	141	1,677	77	
831	AI-12	5,309	17.55	15.12	553	273	150	2,026	85	
819	29.008	5,282	17.05	15.52	482	359	149	1,343	72	
817	29.002	4,994	16.45	15.17	411	277	93	1,254	75	
811	L-35	4,943	16.23	15.23	510	387	510	1,425	85	

Table 8-1. (continued)

Code	Description	Acre Yield		Percent Sugar	Index	PPM			Beet Count
		Gross Sugar	Tons Beets			N	Na	K	
838	AI-10 CMS	4,805	15.24	15.93	427	259	98	1,550	62
815	27.53	4,669	15.57	14.93	366	224	94	1,160	56
837	601 CMS	4,669	17.60	13.72	374	240	97	954	79
830	AI-10	4,579	14.96	15.28	479	336	83	1,464	67
822	133 m <sup>1</sup>	4,504	14.41	15.62	520	326	148	1,731	72
808	201 Rf	4,455	15.79	14.15	533	255	110	1,838	68
801	CT5	4,397	15.62	14.07	369	183	194	1,073	68
803	CT9	4,284	14.69	14.60	461	256	111	1,509	71
809	L-13	3,896	14.85	13.28	541	288	221	1,406	53
	0461S (282)	3,572	11.22	15.92	602	619	99	1,225	63
828	F.C. 601	3,352	12.60	13.28	508	254	140	1,472	67
824	C 515	3,321	11.33	14.60	630	513	141	1,435	44
826	F.C. 504	3,028	10.67	14.22	626	361	153	1,899	53
825	C672	2,543	8.30	15.35	415	273	105	1,304	52
807	SLC 133	1,276	5.23	12.08	826	409	258	2,000	20
Mean of all varieties		5,253	17.53	14.93	499	314	135	1,514	70
S.E. of mean		327.7	1.04	0.299	31.94	35.49	16.31	85.59	4.02
L.S.D. (5% point)		927	2.94	0.84	90	100	46	242	11
C.V. Percent		10.81	10.26	3.46	11.09	19.61	20.87	9.79	9.93
Calculated F		19.62**	19.46**	11.64**	9.26**	6.68**	8.03**	9.64**	10.58**

\*\* Significant at 1% level

Inbreds 27.53, CT5, F.C. 601, L-19, L-36, and 28.19 were significantly better than the mean of all inbreds tested for impurity index. Three inbreds, 0198S, 0461S and C515, were extremely high in amino N. SLC CMS, Ovana 2, NB-1, 27.53 and CT5 were significantly the lowest in amino N. Twelve inbreds had less than 100 ppm of sodium, while SLC 132, SLC 133 and L-13 were high in sodium content. Inbreds 27.53, F.C. 601 and CT5 had low potassium content.

Six CMS equivalents of O-type inbreds were in the test. NB-1, F.C. 506 and AI-10 inbreds had essentially the same values as their equivalent CMS lines for all variables. SLC 129, F.C. 601 CMS and AI-12 CMS yielded significantly more than their equivalents. F.C. 601 CMS also had a significantly lower impurity index and lower potassium content than did F.C. 601.

#### TEST 12

##### Selection Techniques (Individual Roots)

D. L. Doney and J. C. Theurer

Of the 48 segregating lines in this test, 36 (those prefixed by D14--) had been crossed to L35 to obtain curly top resistance. Therefore, differences between these lines are due to the female parent. The remaining 12 lines were progenies from crosses between single-beet selections made in 1968 at Salinas, California. The check variety (UI 7) was planted in each plot to gain an estimate of the environmental variances. All the lines were planted in the greenhouse in paper pots and transplanted in the field when they were 2 weeks old. A considerable amount of damping off occurred in the paper pots and resulted in the loss of a number of roots of some lines. Since the plants were space planted in the field to eliminate competition, the loss of plants in the field did not appreciably affect adjacent plants.

On July 14 two plants were harvested from each plot and data taken on root length, root width, root weight and total plant weight.

The remainder of the plants were harvested on September 20. Each root was weighed and sampled for percent sucrose. From the 2700 plants harvested, 150 roots were selected for seed increase.

The means (table 12-1) and variances (table 12-2) were calculated for each of the segregating lines for each of the characters measured on the July 14 and September 20 harvest dates. There were fewer differences between lines in root length and width than for the other measurements (table 12-1). There were differences between lines within most groups and between groups for root weight and total weight at the July 14 harvest date and for percent sugar, tons per acre and lbs sugar per acre at the September 20 harvest date (table 12-1).

Table 12-1 Means of measurements taken at the July 14 and September 20 harvest dates and correlation coefficients between % sugar and tons/acre for each of the segregating lines.

	July 14 Harvest Date				N	September 20 Harvest Date			r <sup>a</sup>
	Length (cm)	Width (cm)	Root Weight (g)	Total Weight (g)		% Sugar	Tons/ Acre	Lbs sugar per acre X 10 <sup>3</sup>	
D1401	210	43	117	310	90	13.0	23.0	5.9	-.236*
D1402	215	53	163	466	86	12.4	24.0	5.9	-.241*
D1403	218	54	202	457	23	12.6	27.6	7.0	+.230
D1406	149	38	53	310	11	11.0	26.8	5.9	-.154
D1408	232	54	173	497	55	12.1	29.4	7.0	+.011
D1410	203	47	136	429	61	12.6	25.4	6.4	-.122
Mean	206	48	137	329		12.5	25.2	6.3	
F	5.1**	5.7**	9.3**	2.1*		9.2**	9.1**	6.2**	
D1434	228	49	153	425	2	13.5	35.7	9.6	--
D1436	182	54	175	479	54	12.3	26.8	6.6	-.431**
D1438	220	49	142	463	79	13.0	24.2	6.3	-.465**
D1439	199	58	204	604	62	12.9	28.9	7.4	+.105
D1440	211	52	150	478	107	13.1	26.0	6.7	-.518**
Mean	210	52	158	490		12.9	27.2	7.0	
F	1.2	1.3	1.2	2.2**		3.9**	3.1**	3.0**	
D1442	220	50	109	412	62	13.5	25.9	7.0	-.230
D1443	185	60	144	552	16	12.3	30.5	7.4	-.73**
D1444	232	48	118	368	7	11.6	25.3	5.8	+.42
D1445	214	52	151	508	94	12.9	29.3	7.6	-.27*
Mean	214	52	134	460		13.0	28.1	7.3	
F	0.7	0.6	0.8	2.1*		10.9**	5.1**	3.7**	
D1446	219	51	162	477	58	12.3	30.1	--	-.04
D1447	192	59	176	480	112	13.6	26.3	7.1	-.34**
D1448	233	57	198	537	92	12.8	28.7	7.3	-.39**
D1449	237	57	180	494	41	13.0	27.5	7.2	-.33**
D1450	208	46	133	384	97	13.1	27.1	7.0	-.38**
D1451	236	51	139	417	40	13.1	31.0	8.1	-.40**
D1452	221	51	142	379	39	12.6	30.2	7.6	-.43**
D1453	158	44	85	285	7	12.4	28.4	7.0	-.48
D1454	195	46	121	326	6	12.1	25.4	6.1	-.31
D1455	207	54	164	476	40	13.6	27.3	7.4	+.09
D1456	228	52	129	356	18	13.8	27.2	7.5	-.25
D1457	218	46	118	360	48	13.3	24.2	6.4	-.42**
D1458	179	46	95	278	20	13.5	24.7	6.5	-.54**
D1459	214	47	123	341	17	12.5	28.5	7.1	-.47**
D1460	190	47	118	346	33	13.2	26.6	7.0	-.39**
Mean	211	51	147	396		13.0	28.0	7.3	
F	2.2**	3.0**	3.1**	2.2**		7.1**	1.7*	1.6	

Table 12-1 (continued)

	July 14 Harvest Date				N	September 20 Harvest Date				r <sup>a</sup>
	Length (cm)	Width (cm)	Root Weight (g)	Total Weight (g)		% Sugar	Tons/ Acre	Lbs sugar per acre X 10 <sup>3</sup>		
D1461	208	44	106	394	59	12.4	27.0	6.7	-.06	
D1462	231	49	130	410	21	11.6	23.7	5.5	+.21	
D1463	202	43	101	380	4	12.8	29.7	7.6	-.14	
D1464	214	42	96	292	25	11.4	28.7	6.6	+.43*	
D1465	224	50	167	476	52	12.4	24.3	6.0	-.28	
D1468	193	50	126	393	59	12.8	27.7	7.1	+.01	
Mean	212	47	121	391		12.3	26.5	6.5		
F	1.0	1.2	2.4**	2.1**		7.4**	4.1**	5.5**		
ANO 13-1	214	49	207	600	49	9.8	34.1	6.6	-.14	
ANO 13-2	214	53	241	641	119	10.3	30.2	6.1	-.36**	
ANO 14-1	204	59	190	763	79	13.7	29.9	8.2	-.11	
ANO 39	204	57	198	624	30	11.1	32.9	7.3	-.24	
ANO 47	180	70	245	668	14	12.7	30.5	7.8	+.07	
ANO 73	201	57	173	568	64	14.3	27.6	7.8	-.48**	
ANO 74-1	183	65	234	674	13	13.5	26.1	7.1	-.09	
ANO 74-2	177	60	224	604	11	12.9	24.8	6.5	+.25	
ANO 93-1	216	63	254	839	81	11.5	33.9	7.6	-.41**	
ANO 93-2	225	50	223	567	67	10.6	31.1	6.6	-.19	
ANO 94-1	209	53	184	667	59	12.3	29.6	7.2	-.26*	
ANO 94-2	198	65	244	826	17	11.3	33.6	7.6	-.13	
Mean	206	55	208	661		12.4	30.9	7.2		
F	0.7	2.4**	3.7**	3.7**		50.2**	5.2**	10.0**		
UI 7	192	33	82	284	250	12.8	21.8	5.6		

a correlation coefficient between % sugar and tons/acre on a per beet basis

\* Significant differences at  $p = .05$

\*\* Significant differences at  $p = .01$

Table 12-2 Variances of the measurements taken at the July 14 and September 20 harvest dates for each segregating line.

	July 14 Harvest Date				September 20 Harvest Date		
	Length (cm) X 10 <sup>2</sup>	Width (cm)	Root wt (g) X 10 <sup>2</sup>	Total wt (g) X 10 <sup>3</sup>	% Sugar	Tons/ Acre	lbs sugar per acre X 10 <sup>6</sup>
D1401	9.4	29	23.6	6.5	1.08	36.4	2.25
D1402	16.5	56	22.3	20.5	1.52	19.8	1.21
D1403	12.8	43	40.5	10.1	0.64	19.7	1.63
D1406	6.9	53	3.8	8.3	2.38*	39.0	2.51
D1408	20.3	132	25.5	24.7	1.05	54.7	2.46
D1410	13.4	120	22.5	21.6	1.17	54.5	3.31
UI 7	16.5	44	15.4	10.4	1.16	60.8	4.17
D1434	12.6	108	43.6	27.8	0.01	34.1	2.62
D1436	10.4	92	50.8	33.7	1.69	32.9	1.58
D1438	16.7	96	37.5	23.8	1.00	24.6	1.26
D1439	14.5	12	68.0*	27.7*	1.02	--	--
D1440	23.3	120	45.6	48.7*	1.44	37.1	1.92
UI 7	16.5	44	15.4	10.4	1.19	57.5	2.91
D1442	16.1	149*	43.2	23.2	1.36	34.5	2.56
D1443	30.4	28	22.8	15.2	1.19	34.5	1.29
D1444	6.1	13	35.3	22.7	1.48	30.1	2.29
D1445	24.5	208*	69.5*	62.8*	1.44	41.4	2.71
UI 7	16.5	44	15.4	10.4	1.75	68.7	4.32
D1446	27.7	3	17.9	15.9	1.58	--	--
D1447	6.2	53	20.4	16.1	0.64	22.6	1.46
D1448	11.9	74	18.8	23.6	0.78	42.1	2.20
D1449	29.8	60	33.8	21.9	0.81	22.9	1.28
D1450	12.0	39	19.6	9.6	1.22	41.1	2.30
D1451	13.4	67	23.2	24.4	0.76	--	--
D1452	10.2	42	12.6	7.3	1.40	21.6	1.10
D1453	9.1	170*	34.0	23.1	2.30*	40.8	1.92
D1454	25.0	60	51.8	14.5	0.77	43.5	2.51
D1455	9.8	149*	48.0	66.2*	1.60	36.5	3.23
D1456	2.5	2	3.6	5.8	1.70	12.1	1.23
D1457	8.9	55	19.4	30.3	1.16	33.8	2.29
D1458	21.5	42	12.6	8.2	1.68	56.9	3.37
D1459	1.6	75	16.0	12.5	0.73	17.1	0.82
D1460	29.0	204*	75.6*	40.1*	1.36	22.8	1.35
UI 7	16.5	44	15.4	10.4	1.09	71.9	3.93
D1461	28.1	75	12.4	13.1	1.03	26.4	1.90
D1462	8.1	56	11.3	9.0	0.65	39.8	2.40
D1463	11.4	261*	37.3	40.5*	0.40	4.8	0.42
D1464	23.1	113	19.9	16.7	1.40	43.4	3.40
D1465	21.5	96	32.8	32.5	2.19	35.7	2.16
D1468	45.6	51	19.5	18.6	1.16	33.6	2.15
UI 7	16.5	44	15.4	10.4	1.36	58.6	3.10

Table 12-2 (continued)

	July 14 Harvest Date				September 20 Harvest Date		
	Length (cm) X 10 <sup>2</sup>	Width (cm)	Root wt (g) X 10 <sup>2</sup>	Total wt (g) X 10 <sup>3</sup>	% Sugar	Tons/ Acre	lbs sugar per acre X 10 <sup>6</sup>
ANO 13-1	13.6	30	8.3	7.1	1.98	47.9	2.53
ANO 13-2	12.3	57	27.4	12.3	2.30	60.8*	2.19
ANO 14-1	14.6	20	21.3	37.7*	1.95	67.3*	4.86*
ANO 39	4.3	127	30.3	30.4	2.35	67.8*	3.57
ANO 47	1.9	2	5.0	15.4	2.09	27.6	2.86
ANO 73	21.4	117	19.2	18.2	1.87	42.0	2.63
ANO 74-1	14.3	100	48.6	14.1	2.86	14.8	1.50
ANO 74-2	3.1	200*	70.2*	44.6*	2.15	25.4	2.59
ANO 93-1	9.8	67	31.2	57.6*	2.12	57.5*	2.39
ANO 93-2	10.9	30	52.4	8.2	2.59	50.1	2.64
ANO 94-1	7.5	160*	12.0	70.0*	2.07	44.6	2.69
ANO 94-2	16.7	88	32.8	25.4	1.73	114.4*	6.59*
UI 7	16.5	44	15.4	10.4	1.51	35.2	2.81

\* Significant genotypic variance at  $p = .05$

Earlier studies had indicated that segregating lines differ in their percent sugar, yield relationship. Therefore, a correlation between the percent sugar and yield was computed for each line (table 12-1). Most of the correlation coefficients were negative as was expected; however, line D1464 had a significant positive correlation between percent sugar and root yield of .43. There was considerable variation in this relationship. Those lines which exhibited a zero or positive correlation between percent sugar and root yield are the lines that we should be able to achieve improvement in both percent sugar and root yield simultaneously.

An earlier report (1) indicated that greater genetic variances existed earlier in the growing period than at harvest time. In this test the check variety that we had hoped to gain an estimate of the environmental variance from, was so variable that no good estimates could be made for genetic variances (table 12-2). However, there were more significant genetic variances at the July 14 harvest date than the July 20 harvest date.

A correlation of the variances of the measurements made on July 14 with the variances of the measurement made on September 20 revealed no relationships (table 12-3). The means of root width, root weight and total plant weight on July 14 were highly correlated with tons per acre and lbs sugar per acre on September 20. It is interesting to note that the root width had the best correlation (.52) with lbs sugar per acre. More tests are necessary to ascertain the merits of selection in the early part of the growing period.

#### REFERENCES

1. Japanese Bulletin of Sugar Beet Research, Supplement 9, 1967.

Table 12-3 Correlation coefficients between characters measured at the July 14 and September 20 harvest dates for means and variances

July 14	September 20					
	Means			Variances		
	% Sugar	Tons/ Acre	Gross sugar lbs/acre	% Sugar	Tons/ Acre	Gross sugar lbs/acre
Length	-.04	+.06	+.01	-.19	+.07	-.02
Width	+.14	+.38**	+.52**	+.14	+.02	+.08
Rt Wt	-.21	+.48**	+.31*	+.05	-.05	-.02
Total Wt	-.19	+.58**	+.42**	+.17	+.15	+.21

\* Significant differences at  $p = .05$

\*\* Significant differences at  $p = .01$

### TEST 13

#### Nematode Selections

In 1970 at Salinas, California, and at Farmington, Utah, field tests were conducted to evaluate the success of individual beet selection from space-planted field trials. Both tests in 1970 indicated that significant improvement had been achieved. This test was a retest of some of the same material tested in 1970 to further substantiate the results of the 1970 tests.

Five selections from 590-1 and three selections from 590-9 along with each parent and two commercial hybrids were planted in a replicated (6 replicates) field trial at Farmington, Utah. The agronomic practices such as planting, harvesting, etc., have been described earlier.

Individual selections exceeded their parents in gross sugar and root yield in varying degrees. Some were significantly superior to their parents whereas others were essentially not different (table 13-1). Overall, the selections significantly outyielded their parents in gross sugar and root weight (table 13-1). Selections from parent 590-1 were significantly higher than their parent in all other measured factors except sodium (table 13-1). Selections from parent 590-0 were higher than their parent in the other factors but not significantly higher (table 13-1).

#### TEST 14

##### Individual Beet Selections

J. C. Theurer, George K. Ryser, and D. L. Doney

Individual beet selections in three heterogeneous varieties, 0457, 9229 and 0453, were made during the 1968 harvest. For each population, two groups were selected: first, those having a low impurity index and high sugar percentage, and second, those having a high impurity index and low sugar percentage. Selections exceeded the mean of the parental population by at least one standard deviation.

Selected roots of each population were planted in separate seed isolations with the low-index selection in one part of the field and the high-index selection in another, with a large plastic barrier between groups. Genetically sterile plants were tagged and seed was harvested separately from each selfed or sibbed plant.

Eighteen sibbed progenies and 22 selfed progenies of the selections were planted in four replications at Farmington. Parent varieties were included in the test and self and sibbed units were grown in separate parts of the field.

The performance of the sibbed selections in percent of the parental populations is given in table 14-1. With one exception, all of the selections were lower than respective parents for gross sugar and tonnage. Both the high-index and low-index selections, with the exception of code 5 of 0457 population, had non-significant, slightly higher sugar percentage than their respective parent. Code 5 exceeded the parent by 6%. Selection pressure was evident for quality only in the 9229 population where the high-index selection showed significantly higher impurity index than the parent.

Data on selfed progenies of these selections are given in table 14-2. As expected, all selections were lower than the parent in yield of beets and gross sugar. Selections, coded 2 and 8, of the 0457 population had significantly better sugar percentage than the parent.

Table 13-1. Entry means for gross sugar, root weight, percent sugar, index, nitrogen, sodium, potassium and beet count.

Entries	Parent	Gross sugar Lbs/acre	Root weight Tons/acre	% Sugar	Index	Nitrogen (ppm)	Sodium (ppm)	Potassium (ppm)	Beet Count
590-1		9,391	35.4	13.2	598	191	334	1,917	66.1
0109	590-1	10,371	37.4	13.9	611	230	343	1,975	75.5
0707	590-1	10,577	37.9	13.9	640	279	247	2,095	77.5
2006	590-1	10,054	37.8	13.3	688	279	274	2,154	71.7
4408	590-1	9,873	36.1	13.6	663	252	307	2,160	73.1
6805	590-1	10,161	37.3	13.6	726	332	286	2,218	69.7
590-9		10,071	37.5	13.4	659	265	307	2,019	72.5
4809	590-9	11,408	42.3	13.5	666	230	385	2,130	78.2
3804	590-9	10,586	39.1	13.5	714	306	369	2,102	76.3
7701	590-9	10,289	37.3	13.8	690	305	320	2,128	69.8
UI 7		10,027	34.1	14.7	466	224	218	1,529	71.3
Tasco Hybrid #1		10,450	35.2	14.8	420	202	165	1,458	75.7
LSD .05		837	2.57	.53	86	58	69	211	7.5
$\bar{x}$ of 590-1 Sel		10,214**	37.3*	13.7*	666*	274*	291	2,120*	73.5*
$\bar{x}$ of 590-9 Sel		10,758*	39.6*	13.6	690	280	358	2,120	74.7

\* Selections significantly greater than parent at  $P = .05$   
 \*\* Selections significantly greater than parent at  $P = .01$

Table 14-1. Performance of sibbed progenies of individual beet selections in percent of the parent population.

Code	Parentage	Acre Yield			Percent sugar	Index	PPM			Beet Count
		Gross Sugar	Tons Beets				N	Na	K	
16	0457 Parent	100	100	100	100	100	100	100	100	100
7	(0751-10aa)	HI	88	86	103	95	161	88	102	96
6	(0751-7&11aa)	HI	88	87	101	100	176	92	100	94
8	(0751-4aa)	HI	81	80	101	106	217	109	93	94
4	(0750-10aa)	LI	87	84	104	94	174	89	96	97
1	(0750-7aa)	LI	84	87	98	97	177	82	93	101
5	(0750-11aa)	LI	76	72	106	91	184	72	95	75
3	(0750-9&12)	LI	62	62	100	113	224	93	107	53
LSD in percent of parent		17	15	6	24	54	29	18	17	
18	9229 Parent	100	100	100	100	100	100	100	100	100
9	(0752-5,6,7,8aa)	LI	80	79	102	93	84	104	100	49
10	(0753-12aa)	HI	78	85	91	158	141	217	133	85
LSD in percent of parent		19	17	6	22	27	32	16	16	
17	0453 Parent	100	100	100	100	100	100	100	100	100
11	(0754-12&13)	LI	74	72	102	109	126	90	107	43
12	(0754-7,9,10,11)	LI	70	63	110	94	120	63	102	47
13	(0755-9&12aa)	HI	96	95	101	111	117	105	109	91
14	(0755-10aa)	HI	93	95	98	104	111	80	101	77
15	(0755-8-11aa)	HI	107	101	105	88	103	85	88	93
LSD in percent of parent		20	17	6	20	25	27	16	17	
Mean of parent		8316	28.77	14.43	495	251	219	1516	59	
S.E. of Mean		619	1.94	0.31	37.4	22.7	23.1	90.5	4.30	
LSD (5% point)		1750	5.49	0.87	106	64	65	256	12	
CV Percent		14.88	13.49	4.27	15.12	18.10	21.05	11.93	14.61	
Calculated F		3.72**	4.63**	3.40**	6.20**	4.20**	7.17**	4.80**	11.93**	

\*\* Significant at 1% level

Table 14-2. Performance of selfed progenies of individual beet selections in percent of the parent population.

Code	Parentage	Acre Yield			Percent Sugar	Index	PPM			Beet Count
		Gross Sugar	Tons Beets				N	Na	K	
20	0457 Parent	100	100	100	100	100	100	100	100	100
3	(0750-1,3,4,5)	LI	82	81	103	97	105	78	102	90
1	(0750-2)	LI	64	61	104	104	123	71	109	77
2	(0750-6)	LI	63	59	107	88	99	79	95	87
8	(0751-8)	HI	81	77	105	113	124	108	118	88
6	(0751-5)	HI	73	73	100	138	145	87	145	94
4	(0751-1)	HI	68	69	99	116	117	110	113	83
5	(0751-3)	HI	60	60	100	112	125	76	113	89
7	(0751-6&9)	HI	58	58	101	124	138	76	130	69
LSD in percent of parent		9.6	9.9	4.5	23.3	36.0	35.9	16.8	12.0	
22	9229 Parent	100	100	100	100	100	100	100	100	100
9	(0752-1,3,4)	LI	92	93	99	119	137	119	108	72
10	(0753-1&4)	HI	79	87	91	166	175	84	132	97
11	(0753-2)	HI	79	87	91	191	252	146	138	92
12	(0753-3,7,9)	HI	79	83	95	143	180	142	112	101
13	(0753-8)	HI	67	72	93	161	168	186	132	72
LSD in percent of parent		10.8	11.0	4.5	20.7	38.0	35.2	13.4	12.8	
21	0453 Parent	100	100	100	100	100	100	100	100	100
16	(0754-2,5&6)	LI	83	84	99	108	126	88	99	82
14	(0754-1)	LI	77	78	98	95	104	102	86	79
15	(0754-4)	LI	60	61	99	115	135	93	104	58
18	(0755-2)	HI	81	86	94	91	80	125	84	76
17	(0755-1)	HI	79	85	93	116	101	116	112	91
19	(0755-3,4,5)	HI	72	77	93	112	98	131	106	76
LSD in percent of parent		10.6	11.2	4.4	20.4	29.6	42.4	13.9	11.8	
Mean of parent		8064	29.55	13.68	556	282	220	1572	70	
S.E. of Mean		379.7	1.42	0.22	35.42	26.72	26.48	74.16	3.65	
LSD (5% point)		1074	4.00	0.62	101	76	75	210	10.00	
C.V. Percent		9.42	9.59	3.20	12.74	18.97	24.06	9.44	10.45	
Calculated F		11.19**	10.51**	8.75**	14.83**	6.75**	7.38**	13.57**	6.57**	

\*\* Significant at 1% level

All high-index selections of this population showed the trend expected by the selection pressure. All high-index selections of 9229 population had significantly lower sugar percentage and higher impurity index values than the parent. Selection pressure was not evident in the 0543 selfed selections.

These data suggest that a threshold has been reached in high sugar percentage and low impurity index. Further individual beet selection for improvement for these variables appears futile, even though the parents were of divergent origin.

#### Studies using Ethrel as a Gametocide for Sugarbeet

J. C. Theurer and R. E. Wyse

Plants of 0534 and 735, O-type pollinators; A2919, an inbred segregating for O type; 8905 a genotype of almost 100% partial fertility, were plant materials used to study the effects of ethrel on fertility.

In the first experiment plants of 0534, 8905 and A2919 were sprayed with one of the following treatments until runoff: distilled water, 200, 500, 1000, or 3000 ppm showed epinasty in all varieties. At the two higher concentrations, plants stopped growth and leaves and buds became brown and died, stems became black and brittle. The 8905 and 0534 genotypes showed more sensitivity to the chemical than did A2919. The controls were fertile with 90% stainable pollen. Unfortunately some of the 8905 plants were segregating for genetic male sterility. Plants in the 200 and 500 ppm treatments had some brown anther flowers and also some partial-fertile flowers with yellow-brown anthers, but no plants were completely male sterile.

In a second experiment, plants of genotypes A2919 and 8905 were treated with the same concentrations of chemicals, but the chemical was introduced into the plants by mid-vein feeding. A third experiment was conducted with genotype A2919 wherein ethrel was injected by hypodermic needle into leaf axils. In a fourth experiment genotypes 0534 and 735 were sprayed repeatedly at weekly intervals for 3 weeks with the above concentrations of ethrel.

Results of the last three studies were somewhat similar to the first. Use of ethrel as a gametocide for sugarbeets does not look too promising based on these preliminary results. For certain the high concentrations that are so successful with wheat are too phytotoxic to sugarbeets.

## Inheritance and Linkage Studies in Sugarbeets

J. C. Theurer

Mutants and genetic marker stocks have been sought the past few years for linkage studies, particularly to ascertain their possible association with genes governing male sterility. A second objective is to delineate the nine linkage groups of sugarbeets. During 1971 several new homozygous mutants were isolated and crosses have been made or are in the process of being made with these mutants and other genetic marker stocks. These mutants include: pink russet root, russet root, black root, red vein, large cotyledon virescent, white leaf lethal, yellow leaf lethal, yellow leaf, G. W. dwarf, feather leaf, bronze leaf, and broken midrib.

Progenies of six  $F_1$  crosses of some of the above mutants and the  $a_1$  male-sterile gene were evaluated. All plants were fertile and normal indicating the genetic traits are recessive.

$F_2$  progenies involving the self fertility gene ( $s^f$ ), the genetic male-sterile gene ( $a_1$ ), and the pollen-restorer gene ( $R^f$ ), which have been crossed with lines carrying russet root, trout leaf, chlorina, monogermness, and dwarf have been partially evaluated. Data collected to date is too fragmentary to be meaningful and thus will not be given in this report.

## Inheritance of New Sources of Male Sterility

J. C. Theurer

### 66 MSH-242 Source

In 1967 a genetic male sterile was received from Great Western Sugar Company. This line was crossed to Logan material heterozygous for the  $a_1$  gene and also to the annual SLC 03. Results shown in the following table demonstrate that this source is identical with  $a_1$ .

<u>Cross</u>	<u>Generation</u>	<u>Segregation</u>		
		<u>F</u>	<u>MS</u>	<u>P*</u>
MS X 9229-11 ( $A_1 a_1$ )	$F_1$	36	32	
MS X 9229-46 ( $A_1 a_1$ )	$F_1$	29	30	
MS X SLC 03 ( $A_1 A_1$ )	$F_1$	32	0	
	$F_2$	233	80	.80-.90

\* probability for Chi-square test of 3:1 ratio

At Source

A source of male sterility from Beta atriplicifolia was crossed to SLC 129 to determine its inheritance. Segregation in the  $F_2$  indicated that this source was genic rather than CMS as shown below:

Cross	Generation	Segregation		
		F	MS	P*
MS X SLC 129	$F_1$	6	0	
	$F_2$	143	52	.50-.70

\* probability for Chi-square test of 3:1 ratio

We suppose that this sterility is probably the same as  $a_1$ , but this has not been confirmed yet.

StN Source

A male-sterile plant found in a strangle-neck mutant sent to us by Great Western Sugar Company in 1967 was crossed to SLC 129  $A_1A_1$ , and SLC 129  $+ a_1$ . Data collected on this material also indicate that this male sterility is the equivalent of  $a_1$ .

Cross	Generation	Segregation		
		F	MS	P*
MS X 129 $A_1A_1$	$F_1$	23	0	
	$F_2$	235	87	.30-.50
MS X 129 $A_1a_1$	$F_1$	4	5	.70-.80
	$F_2$	160	56	.70-.80

\* probability for Chi-square test of 3:1 ratio for  $F_2$  generations and 1:1 ratio for the  $F_1$  of MS X 129  $A_1a_1$ .

Further Attempts to Develop Haploid Sugarbeet Plants from Pollen

J. C. Theurer

Attempts were continued in 1971 to develop haploid plants from pollen. Several modifications of Nitsch's medium, which is extremely successful in tobacco culture, White's medium, and Heller's medium were tried. Anthers, cotyledons, and roots were aseptically excised and placed on the following agar media:

1. White
2. Heller
3. Nitsch
4. Nitsch minus inositol, folic acid and biotin.
5. Nitsch macronutrients plus Heller's micronutrients.
6. Nitsch plus naphthalacetic acid and ferrous sulfate.
7. Nitsch + IAA.
8. Nitsch + IAA, naphthalacetic acid, and ferrous sulfate.

All media were adjusted to approximately 5.5 pH using HCl or NaOH, and cultures were incubated under light at 25°C in a growth chamber. While some tissues showed swelling, no development of plantlets occurred over a 45-day period.

#### Further Study of Variation in Partial Male Fertility

J. C. Theurer and E. H. Ottley

Four plants (from population 6914 - see 1970 report p. C45) were derived from seed of flowers on a single branch of a male-sterile plant that had reverted to normal pollen fertility. These were studied in 1970 and all four plants were 100% male sterile. Two of these plants were crossed to SLC 03. Seed was harvested, carefully germinated in vermiculite, and the seedlings transplanted into 6" pots. Each flower on each plant of the two progenies was examined as it opened. After complete flowering, the seedstalks were repeatedly cut off and the newly developed inflorescences were observed for fertility until death of the plant. All plants remained completely male sterile throughout the period of the study. No indication of pollen fertility was observed in any flower in the population.

If fertility restoration in the parent plant was due to light, temperature, daylength or other environmental factors, or to aging of the plant, we should have seen some reversion to fertility in the 36 plants we examined this year. Greenhouse conditions during the experiment and the repeated cutback of plants were similar to conditions and procedures used with the original parent plant (6914-14) that showed reversion. One possible suggestion is that pH and callase activity are responsible for the change in fertility as suggested by Izhar and Frankel (Theoretical and Applied Genetics 41:104-108. 1971). We intend to investigate this possibility.

Linkage and Inheritance Studies Involving an Annual Pollen Restorer  
and Other Genetic Characters in Beta vulgaris L.

Theron E. Roundy and J. C. Theurer

An annual fertility-restorer inbred had previously been isolated from a CMS X table beet cross. It was developed through four selfing generations by selecting for high fertility. The emasculated inbred was crossed to an O-type pollinator in order to determine the condition of its cytoplasm.  $F_1$  plants were selfed and pollen counts on the  $F_2$  segregates were made microscopically. Classification of the  $F_2$  progeny yielded 261 fertile and 107 sterile plants. These data fit a 3:1 ratio with a  $\chi^2$  probability of 0.05 - 0.20. The entire  $F_2$  population would have been fertile if the cytoplasm had changed to a normal condition. Thus the fertility which was developed in this inbred can be attributed to genetic factors.

Linkage tests were conducted between the fertility restoration gene, Rf, and four of the known and proposed linkage groups in sugar beets. The following characters were used to test linkage between the Rf gene and their respective linkage group: red hypocotyl, monogermness, virescens and Mendelian sterility. The crosses were made by emasculation of the inbred for use as the female with stocks of the respective characters as pollinators. In some instances, the restorer inbred was utilized as the pollinator when male sterility was available in the other marker lines.

The following table shows the segregation between Rf and R in the  $F_2$  and BC<sub>1</sub> generations. Data from the backcross gave a good fit to the expected ratio indicating independence of the two genes.  $F_2$  data fit the expected 9:3:3:1 ratio with only 1% significance. However, when the  $\chi^2$  value was partitioned into its three components, it was evident that the difference was due to the deviation of the single genes from their expected proportions and not to linkage between the genes.

Genes	Linkage phase	Number of individuals				Total	$\chi^2_x$	$\chi^2_y$	$\chi^2_L$
		XY	Xy	xY	xy				
Rf R	R F <sub>2</sub>	140	68	38	12	258	4.34*	4.96*	2.11
	R BC <sub>1</sub>	18	26	24	15	83	.31	.01	3.48*

\* 5% point of significance

Data for the remaining linkage tests are not complete at this time.

## Physiological Genetics

Devon L. Doney

### Mitochondrial Respiration

#### (1) Introduction

A rapidly growing plant requires substantial amounts of ATP (adenosine triphosphate) to drive energy-requiring reactions (growth, protein synthesis, ion uptake, etc.). Since this energy (ATP) is provided largely by the mitochondria, more efficient mitochondrial species can potentially offer more energy for growth. Thus, the faster growth of hybrids, as compared to their parental inbreds may be due in part to more efficient mitochondria.

A correlation between heterosis and high mitochondrial oxidation and phosphorylation has been reported in maize (3, 4), barley (2), and wheat (5). The mitochondrial oxidation and phosphorylation of mixtures of mitochondria from maize (3, 4), barley (2), and wheat (5) inbreds (complementation) were also highly correlated with the hybrid vigor of the respective hybrids.

Techniques have been developed for the isolation and measurement of oxidative phosphorylation of tightly coupled mitochondria from sugarbeet root (1). A number of studies have been initiated to measure the mitochondrial efficiency of hybrids, inbreds and 1:1 mixtures of the two inbreds at different stages of growth.

Respiratory control (R:C) ratios which give an indication of the integrity of the mitochondria are calculated as ratios of state 3 (ADP stimulated respiration, substrate present) to state 4 (depressed respiration, ADP depleted, substrate present). The ADP:O ratios (microatoms oxygen utilized per micromole ADP converted to ATP) are calculated according to Chance and Williams (1, 2).

#### (2) Mitochondrial respiration of hybrids, inbreds, and 1:1 mixtures (complementation)

##### (a) Hybrids from 1970 field trial

A series of seven hybrids were selected from the 1970 field trials. A root sample was taken from each hybrid at harvest time and stored at 5°C. Approximately one month after storage began, mitochondrial respiration was measured on the stored roots for differences in efficiency of the seven hybrids.

Hybrid 133 CMS X O198S gave significantly lower R:C and ADP:O ratios than the other hybrids (table 1). There were no differences between the remaining hybrids (table 1). There were significant

differences in root yield between the hybrids (table 1). Negative, but not significant, correlations were found between root yield and R:C ratio, ADP:O ratio, and state 4. A significant negative correlation was obtained for root weight and state 3.

The same hybrids were combined in 1:1 mixtures with each other and respiration in mixtures vs the respiration of the mean of the two components measured. The mean effect of each hybrid summed over combinations it appeared in are shown in table 2. Only for the R:C ratio for hybrid 133 CMS X 0198S was there a significant increase in the 1:1 mixtures over the mean of the components.

Since these were hybrids, increases were not expected in the 1:1 mixtures, but a good positive correlation between root yield and R:C and ADP:O ratios was expected.

(b) Photo-thermally induced inbreds

Several inbreds which had previously been photo-thermally induced during the winter months at St. George, Utah, were tested for mitochondrial complementation. Since the roots were small, several roots were used for each mitochondrial isolation. Each inbred combination was replicated between five and nine times.

Combination RW467 and Acc 107 gave significant R:C and ADP:O ratio increases over the components (tables 3 and 4). Previously, this combination exhibited heterosis in field trials. The 590-1 and 590-9 combination is closely related and gave no evidence of complementation for heterosis (tables 3 and 4). The remaining combinations gave small increases in R:C and ADP:O ratios over their respective components (tables 3 and 4). With the exception of combination CT9 CMS and C 6600, which has not been field tested, these combinations have shown moderate heterosis in field tests. These results indicate that complementation for heterosis may be evident in sugarbeet.

(c) Mitochondrial complementation of sugarbeet grown in the greenhouse

Five hybrids and their inbred parents were grown in the greenhouse in large boxes. One plant of each entry was transplanted at random in each of nine boxes. This resulted in a randomized-block design of nine replicates with boxes as blocks. When the plants were 10 weeks old, mitochondria were isolated from each root and respiration measurements taken on each root and 1:1 mixtures of the inbreds (tables 5 and 6).

A non-significant increase in R:C and ADP:O ratios was obtained for all 1:1 mixtures over the mean of the components except for combination 929 CMS and 128 (tables 4 and 5). These two lines are closely related and were not expected to exhibit heterosis. The ratios for the hybrids were close to those obtained in the 1:1 mixtures.

These data are not conclusive, but tend to suggest that complementation for heterosis exists in sugarbeet.

(d) Complementation in bolting beets

Mitochondria were isolated from the roots of eight bolting inbreds and combined in 1:1 mixtures with all other inbreds in a diallel type of arrangement. Mitochondrial respiration was measured and the R:C (table 7) and ADP:O (table 8) ratios computed. The mean of the mixtures was higher than the component inbred means for all inbreds for both R:C and ADP:O ratios (tables 7 and 8). Mixtures involving inbreds A927, A919 and A925, significantly exceeded the midparent (table 8). The combining ability of these inbreds is not known, so a comparison between combining ability and mitochondrial complementation cannot be made. The data do suggest that complementation exists in sugarbeet.

(e) Mitochondrial respiration and complementation at different stages of growth

The previous experiments gave some, but not conclusive, evidence that the phenomenon of mitochondrial complementation exists in sugarbeet. This test was set up as a more thorough investigation of this phenomenon.

Twelve hybrids (known to exhibit different levels of heterosis) and their inbred parents were planted in a replicated (six replicates) field trial.

Mitochondrial respiration measurements were made at three different stages of growth: (1) July 27-30 (2) August 23-27 and (3) roots harvested October 13 and stored at 5°C for 2 weeks. Two roots from each replicate for each line were used for mitochondria isolation for the July and August measurements. For the stored measurements, one field replicate was stored and four 2-beet samples were taken from each line for mitochondrial respiration measurements.

The remaining five replicates were harvested October 14 and data taken on top weight, root weight, percent sugar, amino nitrogen, sodium and potassium.

There were differences between the hybrids (table 9) and inbreds (table 10) for most of the measurements. The hybrids had a higher percent sugar and greater root weight than the inbreds, whereas, the inbreds slightly exceeded the hybrids in top weight (tables 9 and 10).

Since the hybrids exceeded the inbreds in root weight and the inbreds exceeded the hybrids in top weight, it seemed desirable to relate these measurements with the mitochondrial measurements. A correlation was computed between the mitochondrial oxidation

measurements and top weight, root weight, total weight, percent sugar, and gross sugar at each sampling date. The correlation of the ADP:O ratios at each of the sampling dates with the above field measurements is given in table 11.

This relationship of ADP:O ratio with top weight varied considerably for sampling date. No relationship of ADP:O ratio with percent sugar was observed (table 11). The correlation of ADP:O ratio with root weight and gross sugar was positive on all three sampling dates and significant when summing over the three dates (table 11). This indicates that the efficiency of the mitochondria has some effect on root yield and gross sugar.

The root weight, total weight and percent sugar for the hybrids and their component inbred along with the R:C and ADP:O ratios at the three sampling dates for the hybrids, the component inbreds and the 1:1 mixtures of the inbreds are given in table 12. All hybrids exhibited heterosis (greater than the mid-parent) for root weight and all but one showed heterosis (greater than the mid-parent) for total weight and percent sugar (table 11). The biochemical integrity (R:C) and mitochondrial efficiency (ADP:O) was very good at the July 27-30 sampling date, but decreased with each succeeding sampling (table 12). The hybrids exceeded the inbreds in R:C and ADP:O ratios at each sampling date (table 12). The ADP:O ratio of the 1:1 mixtures exceeded the mean of the two inbred components for the July 27-30 date but was less at the other two dates.

We also computed the correlations between mitochondrial complementation (ADP:O differences between the 1:1 mixture and the mean of the component inbreds) and observed heterosis (greater than the mid-parent) for root weight, total weight and percent sugar (table 13). There was a highly significant correlation between ADP:O complementation and heterosis for root yield and total weight at the July 27-30 date (table 13). The relation between complementation and heterosis was much less at the other two dates (table 13). The combined correlations over the three dates gave significant correlations for root weight and total weight (table 13).

The mitochondria isolated on the July 27-30 date were the most efficient, which is probably indicative of the fast rate of growth at that time. Complementation for heterosis appears to be a significant factor at this stage of growth. However, there were very small differences (between lines) in mitochondria (ADP:O) efficiency. Even though mitochondrial complementation does seem to be a factor at certain stages of growth, the differences are too small to make this technique an important breeding tool in sugarbeet.

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Table 1. R:C and ADP:O ratios and State 3 and 4 oxidation rates from mitochondria isolated from 7 hybrids and their corresponding root yields in 1970.

Hybrids	R:C	ADP:O	State 3 <sup>a</sup>	State 4 <sup>a</sup>	Root yield tons/acre
133 CMS X 0198S	1.84	1.30	39.0	27.4	26.7
UI #7 (ck)	2.10	1.50	50.2	26.7	22.4
129 CMS X 0461	2.12	1.65	57.5	31.9	21.5
129 CMS X L-19	2.02	1.46	54.1	31.1	20.5
CT9 CMS X 129	2.11	1.48	36.8	20.8	22.4
128 CMS X 0461	2.28	1.55	52.8	29.9	15.8
CT9 CMS X CT8	2.25	1.62	37.3	23.0	24.2
LSD .05	.25	.20	16.1	10.5	2.6

a =  $\mu$  moles  $O_2$ /min/mg mitochondrial protein

Table 2. Mean differences between 1:1 mixtures (each hybrid in combination with all other hybrids) and the mean of the two components for R:C and ADP:O ratios and state 3 and 4 oxidation rates.

	R:C	ADP:O	State 3 <sup>a</sup>	State 4 <sup>a</sup>
133 CMS X 0198S	+ .29*	+ .01	+ 5.5	-1.9
UI #7 (ck)	+ .21	+ .12	+ 4.3	-0.4
129 CMS X 0461	- .06	- .04	-10.0	-5.0
129 CMS X L-19	+ .01	- .10	- 2.0	-2.4
CT9 CMS X 129	- .01	- .03	- 6.4	-3.8
128 CMS X 0461	- .02	- .10	+ 4.0	+1.9
CT9 CMS X CT8	+ .12	+ .06	- 7.7	-5.8
Mean	+ .08	- .03	- 1.7	-2.5

\* = Significantly different from zero at  $p = .05$

a =  $\mu$  moles  $O_2$ /min/mg mitochondrial protein

Table 3. Respiratory control ratios (R:C) from mitochondria isolated from photothermally induced roots of inbreds and their 1:1 mixtures.

Inbred Combinations		R:C Ratios			
Inbred 1	Inbred 2	Inbred 1	Inbred 2	1:1 mixture	LSD.05
RW 467	Acc 107	1.38	1.44	1.96	0.43
590-1	590-9	1.69	1.54	1.67	0.21
L53 CMS	SLC 129	1.92	2.09	2.10	0.34
SLC 129 CMS	EL 32	1.71	1.77	1.84	0.25
EL 32 CMS	CT9	1.99	1.84	2.12	0.38
CT9 CMS	c6600	1.88	2.05	2.14	0.16

Table 4. ADP:O ratios from mitochondria isolated from photothermally induced inbreds and their 1:1 mixtures.

Inbred Combinations		ADP:O Ratios			
Inbred 1	Inbred 2	Inbred 1	Inbred 2	1:1 mixture	LSD.05
RW 467	Acc 107	1.20	1.08	1.46	0.30
590-1	590-9	1.04	1.01	1.05	0.17
L53 CMS	SLC 129	1.43	1.46	1.58	0.16
SLC 129 CMS	EL 32	1.45	1.49	1.59	0.23
EL 32 CMS	CT9	1.43	1.31	1.65	0.46
CT9 CMS	c6600	1.38	1.58	1.61	0.22

Table 5. Mitochondrial R:C ratios for inbreds, 1:1 mixtures of inbreds and hybrids.

Inbred Combination		R:C Ratios				
Inbred 1	Inbred 2	Inbred 1	Inbred 2	1:1 mixture	Hybrid	LSD.05
929 CMS	953	1.23	1.44	1.64	1.63	0.41
953 CMS	128	1.89	1.54	1.86	1.81	0.50
929 CMS	CT9	1.34	1.68	1.59	1.55	0.40
929 CMS	EL 32	1.90	1.63	1.85	1.89	0.44
929 CMS	128	1.15	1.54	1.35	-	0.42

Table 6. Mitochondrial ADP:O ratios for inbreds, 1:1 mixtures of inbreds and hybrids.

Inbred Combinations		ADP:O Ratios				
Inbred 1	Inbred 2	Inbred 1	Inbred 2	1:1 mixture	Hybrid	LSD.05
929 CMS	953	0.88	1.05	1.18	0.98	0.13
953 CMS	128	1.33	1.16	1.39	1.41	0.21
929 CMS	CT9	0.97	1.34	1.12	1.05	0.19
929 CMS	EL 32	1.27	1.10	1.32	1.41	0.20
929 CMS	128	0.80	1.16	0.91	--	0.16

Table 7. Mitochondrial ADP:O ratios of eight inbreds and 1:1 mixtures from roots of bolting beets.

Inbred	Self	Rest	*1:1 mixture	LSD .05
A927	1.26	1.32	1.48	0.20
A919	1.69	1.59	1.75	0.15
929	1.51	1.50	1.70	0.19
A925	1.58	1.50	1.73	0.15
51214	1.55	1.51	1.65	0.22
953 CMS	1.51	1.56	1.68	0.08
A921	1.50	1.54	1.74	0.17
929 CMS	1.58	1.64	1.83	0.15

\* = mean 1:1 mixture of inbred with all other inbreds.

Table 8. Mitochondrial R:C ratios of eight inbreds and 1:1 mixtures from roots of bolting beets.

Inbred	Self	Rest	*1:1 mixture	LSD .05
A927	1.79	1.85	2.07	.22
A919	2.46	2.21	2.65	.33
929	2.16	2.13	2.37	.38
A925	2.22	2.11	2.38	.20
51214	2.11	2.11	2.39	.30
953 CMS	2.16	2.33	2.32	.22
A921	2.08	2.20	2.37	.41
929 CMS	2.43	2.47	2.77	.45

\* = mean 1:1 mixture of inbred with all other inbreds.

Table 9. Top weight, root weight, total weight, gross sugar, percent sugar, index, nitrogen, sodium, potassium, and beet count for each of the hybrids tested.

Description	Top Weight Tons/Acre	Root Weight Tons/Acre	Total Weight Tons/Acre	Gross Sugar Lbs/Acre	% Sugar	Index	Nitrogen (ppm)	Sodium (ppm)	Potassium (ppm)	Beet Count
0v CMS X 0198S	15.2	22.2	37.5	6,420	14.4	594	445	163	1,419	81
0v CMS X CT9	16.0	22.7	38.6	6,452	14.2	499	328	135	1,334	74
CT9 X 0v 1	18.7	22.4	41.0	6,568	14.6	474	317	137	1,311	81
0v CMSX (133Xm <sup>1</sup> )	17.5	20.6	38.1	5,977	14.5	560	353	205	1,551	72
129 X A7134	22.4	24.5	47.0	7,104	14.5	428	262	162	1,200	75
133 CMS X 0461S	23.5	20.0	43.6	6,076	15.2	412	304	165	1,047	69
0v CMS X 0461S	19.0	18.4	37.4	5,515	15.0	529	474	122	1,094	78
CT9 CMS X 0461S	27.0	19.6	46.6	5,587	14.3	437	258	160	1,244	75
129 CMS X 0461S	22.2	15.8	38.0	4,584	14.5	418	257	166	1,169	56
133 X L-19	16.2	18.7	35.0	6,192	16.5	432	325	160	1,321	55
0v CMS X A7135	18.3	21.7	40.0	6,195	14.2	550	383	160	1,374	79
(129X133) X A7134	21.1	23.8	44.3	6,832	14.4	500	313	188	1,356	79
LSD	3.5	2.0	4.4	646	.63	71	89	36	153	5.8

Table 12. Root weight, total weight and percent sugar for each hybrid and its component inbreds and the R:C and ADP:O ratios at each sampling date for each hybrid, its component inbreds and the 1:1 mixture of the component inbreds.

	Root weight Tons/acre	Total weight Tons/acre	% Sugar	July 27-30		Aug 23-27		Stored 5 C	
				R:C	ADP:O	R:C	ADP:O	R:C	ADP:O
0vCMS X 0198 S	22.2	37.5	14.4	2.77	2.37	2.58	1.96	1.79	1.71
0vCMS	20.0	45.5	14.1	2.25	1.99	2.26	2.03	1.64	1.45
0198 S	16.1	26.5	14.0	2.18	2.00	2.56	2.01	1.69	1.58
Mixture				2.17	2.00	2.46	1.92	1.62	1.49
0vCMS X CT9	22.7	38.6	14.2	2.96	2.25	3.09	1.97	1.96	1.65
0vCMS	19.5	40.9	14.3	2.73	2.43	2.61	2.30	1.67	1.40
CT9	15.6	29.7	13.5	3.00	2.35	2.54	1.98	1.45	1.25
Mixture				2.45	2.42	2.44	1.92	1.42	1.26
CT9 CMS X 0v 1	22.4	41.0	14.6	2.80	2.28	2.90	1.97	2.25	1.91
CT9 CMS	21.7	48.2	13.4	2.98	2.29	2.68	2.11	2.68	1.94
0v 1	13.5	31.8	13.9	2.39	2.25	2.47	2.09	1.47	1.37
Mixture				2.58	2.27	2.49	2.10	1.79	1.47
0vCMS X (133 X m <sup>1</sup> )	20.6	38.1	14.5	2.64	2.22	2.79	1.98	1.86	1.75
0vCMS	19.8	40.4	14.5	2.43	2.37	2.58	2.01	1.90	1.55
133 X m <sup>1</sup>	10.0	22.6	14.1	2.11	1.94	2.20	1.79	1.85	1.60
Mixture				2.24	2.25	2.05	1.89	1.66	1.47
129 CMS X A7134	24.5	47.0	14.5	2.45	2.20	2.78	2.01	1.88	1.69
129 CMS	17.3	38.3	14.0	2.85	2.46	2.29	1.86	1.89	1.49
A7134	19.9	46.5	14.0	2.44	2.11	2.98	2.02	1.88	1.56
Mixture				2.49	2.31	2.71	1.97	1.75	1.50
133 CMS X 0461 S	20.0	43.6	15.2	2.54	2.34	2.59	2.13	1.68	1.39
133 CMS	14.9	31.3	13.8	2.20	2.04	2.13	1.80	1.64	1.42
0461 S	8.5	37.0	13.0	2.73	2.37	2.68	2.02	1.69	1.54
Mixture				2.57	2.37	2.27	1.90	1.60	1.32

Table 11. Correlation coefficients between ADP:O ratios and top weight, root weight, total weight, percent sugar and gross sugar for each sampling date.

	Top Weight	Root Weight	Total Weight	% Sugar	Gross Sugar
July 27-30	-.03	.40	.21	-.10	.40
August 27-30	.66*	.17	.70	.11	.34
Stored 5 C	-.63*	.52*	-.26	-.23	.43
$\bar{x}$ of 3 samplings	-.36	.67**	.09	-.35	.59*

\* Significantly different than zero at  $p = .05$

\*\* Significantly different than zero at  $p = .01$

Table 12. Root weight, total weight and percent sugar for each hybrid and its component inbreds and the R:C and ADP:O ratios at each sampling date for each hybrid, its component inbreds and the 1:1 mixture of the component inbreds.

	Root weight Tons/acre	Total weight Tons/acre	% Sugar	July 27-30		Aug 23-27		Stored 5 C	
				R:C	ADP:O	R:C	ADP:O	R:C	ADP:O
OvCMS X 0198 S	22.2	37.5	14.4	2.77	2.37	2.58	1.96	1.79	1.71
OvCMS	20.0	45.5	14.1	2.25	1.99	2.26	2.03	1.64	1.45
0198 S	16.1	26.5	14.0	2.18	2.00	2.56	2.01	1.69	1.58
Mixture				2.17	2.00	2.46	1.92	1.62	1.49
OvCMS X CT9	22.7	38.6	14.2	2.96	2.25	3.09	1.97	1.96	1.65
OvCMS	19.5	40.9	14.3	2.73	2.43	2.61	2.30	1.67	1.40
CT9	15.6	29.7	13.5	3.00	2.35	2.54	1.98	1.45	1.25
Mixture				2.45	2.42	2.44	1.92	1.42	1.26
CT9 CMS X Ov 1	22.4	41.0	14.6	2.80	2.28	2.90	1.97	2.25	1.91
CT9 CMS	21.7	48.2	13.4	2.98	2.29	2.68	2.11	2.68	1.94
Ov 1	13.5	31.8	13.9	2.39	2.25	2.47	2.09	1.47	1.37
Mixture				2.58	2.27	2.49	2.10	1.79	1.47
OvCMS X (133 X m')	20.6	38.1	14.5	2.64	2.22	2.79	1.98	1.86	1.75
OvCMS	19.8	40.4	14.5	2.43	2.37	2.58	2.01	1.90	1.55
133 X m'	10.0	22.6	14.1	2.11	1.94	2.20	1.79	1.85	1.60
Mixture				2.24	2.25	2.05	1.89	1.66	1.47
129 CMS X A7134	24.5	47.0	14.5	2.45	2.20	2.78	2.01	1.88	1.69
129 CMS	17.3	38.3	14.0	2.85	2.46	2.29	1.86	1.89	1.49
A7134	19.9	46.5	14.0	2.44	2.11	2.98	2.02	1.88	1.56
Mixture				2.49	2.31	2.71	1.97	1.75	1.50
133 CMS X O461 S	20.0	43.6	15.2	2.54	2.34	2.59	2.13	1.68	1.39
133 CMS	14.9	31.3	13.8	2.20	2.04	2.13	1.80	1.64	1.42
O461 S	8.5	37.0	13.0	2.73	2.37	2.68	2.02	1.69	1.54
Mixture				2.57	2.37	2.27	1.90	1.60	1.32

Table 12. (continued)

	Root weight Tons/acre	Total weight Tons/acre	Sugar %	July 27-30		Aug 23-27		Stored 5 C R:C	
				R:C	ADP:0	R:C	ADP:0	R:C	ADP:0
0v CMS X 0461 S	18.4	37.4	15.0	2.13	2.09	2.52	1.97	1.82	1.68
20.0	45.5	14.1	2.25	1.99	2.09	1.78	1.77	1.53	1.53
7.9	35.4	13.2	3.02	2.09	2.22	2.02	1.87	1.64	1.64
Mixture			2.28	1.98	2.08	1.74	1.69	1.51	1.51
CT9 CMS X 0461 S	19.6	46.4	14.3	2.58	2.27	2.77	2.11	1.64	1.47
CT9 CMS	21.7	48.2	13.4	2.64	2.09	2.66	2.13	2.16	1.84
0461 S	8.5	37.0	13.0	2.65	2.06	2.61	1.91	1.74	1.65
Mixture			2.65	1.95	2.48	2.05	1.84	1.51	1.51
129 CMS X 0461 S	15.8	38.0	14.5	2.31	2.20	2.53	1.94	1.68	1.49
129 CMS	17.6	37.0	14.2	2.64	2.04	2.20	1.81	1.81	1.57
0461 S	7.9	35.4	13.2	3.00	2.18	2.38	1.92	1.76	1.44
Mixture			2.65	2.08	2.20	1.90	1.63	1.48	1.48
133 CMS X L19	18.7	35.0	16.5	2.52	2.25	2.53	1.94	1.95	1.61
133 CMS	14.9	31.3	13.8	2.13	1.66	2.23	1.78	1.66	1.37
L19	14.2	35.7	16.6	2.78	1.96	2.53	1.79	1.65	1.45
Mixture			2.13	1.74	2.41	1.90	1.57	1.57	1.39
0v CMS X A7135	21.7	40.0	14.2	2.43	2.27	3.04	2.07	2.04	1.89
0v CMS	19.8	40.4	14.5	1.99	1.53	2.00	1.55	1.67	1.49
A7135	17.5	39.2	14.2	2.25	1.92	1.99	1.48	1.92	1.60
Mixture			1.90	1.68	2.04	1.36	1.57	1.57	1.42
LSD .05	2.1	4.7	.6	.45	.20	.54	.32	.40	.34
Mean of hybrids	20.6	40.2	14.7	2.56	2.20	2.74	1.99	1.87	1.66
Mean of inbreds	15.8	37.4	13.9	2.53	2.07	2.40	1.92	1.79	1.53
Mean of mixtures				2.37	2.09	2.33	1.87	1.65	1.44
LSD .05	.6	.15	.12	.06	.14	.09	.11	.11	.10

Table 13. Correlation coefficients between complementation (difference between 1:1 mixture and the mean of the component inbreds) for ADP:O ratios and heterosis (greater than the mid-parent) for root weight, total weight and percent sugar at each sampling date.

	Root wt	Total weight	% Sugar
July 27-30	.75**	.70**.	.01
August 27-30	.12	.33	.42
Stored 5 C	-.14	-.15	-.45
$\bar{x}$ of 3 samplings	.47*	.59*	.07

\* Significantly different than zero at  $p = .05$

\*\* Significantly different than zero at  $P = .01$

### (3) Physiological Studies of Mitochondrial Respiration

#### (a) Environmental effects on mitochondrial respiration

This experiment was designed to test the effect of stored vs fresh beets and time of day on mitochondrial respiration.

Mitochondria were isolated from beets stored for 24 hrs at 5 C and from beets freshly dug out of the ground. The respiration measurements (R:C and ADP:O Ratios, and state 3 and state 4 oxidation rates) showed better ratios and rates for the stored beets (table 14). There was no difference in R:C and ADP:O ratios throughout the day, but there was a steady decrease in state 3 and state 4 oxidation rates from morning to afternoon (table 14).

#### (b) Effect of storage time on mitochondrial respiration

Because of the apparent increase in respiration efficiency of stored beets over fresh beets, an experiment was set up to measure the effect of storage at different temperatures. It is also well known that injured or cut beets have a marked increase in total beet respiration. Therefore, we also wanted to see if injury or trimming affected the mitochondrial respiration. A factorial experiment was set up using beets stored at 5 and 23 C and clean undamaged vs trimmed beets (outside epidermal area completely removed). Mitochondrial respiration was measured for these four treatments at 0, 2, 4, 8, 16, 24, 48, and 72 hrs of storage.

There was no difference in hours of storage for any of the treatments. An increase in the R:C ratio and a significant increase in the ADP:O ratio of trimmed over whole beets was observed at the 5 C storage temperature (table 15). This treatment (trimmed at 5 C storage) was the only treatment that showed a significant increase in mitochondrial respiration (table 15).

#### Isozyme Studies

##### (1) Glucose-6-phosphate dehydrogenase (G-6-PD)

Immature anthers in the pro-pollen stage and mature anthers were collected separately from two male-sterile and two normal plants in a population segregating for male sterility. Approximately 300 anthers were collected for each sample. The samples were ground in a glass homogenizer and centrifuged at 20,000 xg for 10 min. The resulting supernatant (.5 ml) was saved for electrophoresis in acrylamide gels. Electrophoresis was carried out on each sample (.05 ml) for 2 1/2 hrs, after which they were stained histochemically for G-6-PD. All samples contained two bands, representing two isozymes of G-6-PD. The first band was sharp and identical in all samples. The second band was much larger and broader and appeared to be similar in all samples except the pro-pollen sample from male-sterile plants. This band was much tighter and migrated less than the second band of the other samples. There appears to be a different isozyme of G-6-PD in the pro-pollen anthers of male-sterile plants than in pro-pollen anthers of normal plants, but there was no difference in isozymes of G-6-PD in mature anthers. Further tests with other lines need to be conducted to verify this observation.

Table 14. Mitochondrial respiration measurements for beets stored at 5 C vs fresh beets and at different times during the day.

Treatment	R:C	ADP:O	State 3	State 4
<u>Storage</u>				
24 hrs 5 C	2.25 a*	1.74 a	96.8 a	43.0 a
Fresh	2.03 b	1.60 b	78.5 b	38.6 a
<u>Time of day</u>				
8:30 AM	2.23 a	1.70 a	118.3 a	52.6 a
10:00 AM	2.00 a	1.58 a	87.2 b	43.7 b
12:30 PM	2.16 a	1.73 a	78.0 bc	36.0 c
3:00 PM	2.17 a	1.67 a	67.1 c	31.0 d

\* data followed by the same letter are not significantly different at  $p = .05$

Table 15. R:C and ADP:O ratios of trimmed and whole beets stored at 5 and 23 C.

Measurement	Temperature	Trimmed	Whole Beet
R:C	5°	2.02	1.79
R:C	23°	1.95	2.02
ADP:O	5°	1.80*	1.57
ADP:O	23°	1.60	1.60

\* significantly larger at  $p = .05$

## Errors Inherent in the Determination of Purity

Roger Wyse and Richard Thomas<sup>1/</sup>

### INTRODUCTION

The determination of purity, particularly in clear juice samples, is a widely used method for assessing sugarbeet quality. Percentage purity is the ratio of sucrose (determined by polarimetry) to total soluble solids (determined by refractive index). Both determinations make the basic assumption that all compounds in the sample have the same optical properties as sucrose. Since sucrose is usually 75-95% of the total solids in most samples, this assumption is valid for most uses. When purity is used to predict RWST from clear juice samples, small deviations from these assumptions become increasingly important. An important aspect of post-harvest studies is the accumulation of impurities. The non-sucrose content of clear juice samples is normally determined by the following method:

$$\frac{100 - \text{CJP}}{\text{CJP}} = \frac{\text{gms of impurities}}{100 \text{ gms of sucrose}}$$

Again small changes in CJP make a large difference in total apparent impurities. Under storage conditions where large amounts of impurities accumulate, the sum of the analyzed impurities (raffinose, glucose, fructose, betaine, amino acids, etc.) will often be greater than the apparent total impurities calculated as shown above. Correcting the apparent percent sucrose for optically active compounds such as raffinose will eliminate this problem in some, but not all cases.

The purpose of this study was to determine the effect of several major impurities on the total solids content as determined by refractive index.

### MATERIALS AND METHODS

A stock solution of exactly 10% sucrose was prepared. This stock solution was then divided among eight 500 ml volumetric flasks thus assuring each to have the same initial refractive index. Stock solutions were prepared for sucrose, betaine, fructose, glucose, raffinose, sodium and potassium. Sodium and potassium were added as chloride salts. An exact volume containing 2400 mg of an impurity was then added to one of the 500 ml flasks containing 10% sucrose. Seventeen different dilutions were prepared for each impurity using the stock 10% sucrose solution for dilution. Three sets of seventeen

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dilutions were measured and for each dilution the dry matter per 100 ml was calculated. Refractive index measurements were made on a Bausch and Lomb Precision Refractometer at 20 C.

#### RESULTS AND DISCUSSION

The results for each impurity and sucrose was plotted as actual soluble dry matter vs refractive index. From the slope of these plots the following relationships were calculated:

1 gm of NaCl	= 1.19 gm of sucrose
" Betaine	= 1.12 " "
" KCl	= .89 " "
" Raffinose	= .84 " "
" Glucose or fructose	= .99 " "

Therefore, a solution containing the following per 100 ml:

$$\begin{array}{r} 10 \text{ gms of sucrose} \\ 1 \text{ gm of raffinose} \\ \hline 11 \text{ gms total D.M.} \end{array}$$

would appear as:  $10 + 1 \times .84 = 10.84$  gms by refractometric calculations. In actual practice the correction factors would tend to cancel each other, i.e., 1 gm of KCl would nullify 1 gm of betaine. However, raffinose would appear to be a very important impurity since it must be subtracted from polarimetric determinations of sucrose and added to the refractometric dry matter determination.

For example:

A clear juice sample of 15% sucrose with an RDS of 15.78 and 2 mg/ml raffinose would have an uncorrected purity of 95%. Correcting for raffinose:

$$\begin{aligned} \text{Corr \% S} &= \% \text{ S} - \frac{1.59 \times \text{mg/ml raffinose}}{10} \\ &= 15 - 1.59 \times .2 = 14.68 \end{aligned}$$

$$\text{Corr RDS} = \% \text{ RDS} + \frac{2 \text{ mg/ml}}{.84 \times 10} = 15.78 + .24 = 16.02$$

The corrected purity is now:

$$\frac{14.68}{16.02} = 91.6$$

The uncorrected non-sugar content would be 5.26 gm/100 gms sucrose but corrected would be 9.17.

#### SUMMARY AND CONCLUSIONS

Non-sucrose compounds may cause substantial errors not only in the polarimetric determination of sucrose but also in the refractometric determination of total soluble solids. These errors may explain some discrepancies found in studies involving critical analyses of non-sucrose compounds in clear juice samples.

## Protein Metabolism during Short Term Storage of Sugarbeet Roots

Roger Wyse

During storage at temperatures below approximately 5 C, the amino acid content of sugarbeet roots declines, while at temperatures above 5 C, the amino acid content increases. This response to temperature was postulated to be reflective of a temperature effect on protein metabolism and not merely that of the amino acids (Wyse *et al.*, 1971).

This experiment was designed to determine the effect of temperature on the protein and amino acid content of sugarbeet roots at storage temperatures of 5 and 25 C over a 14-day period.

### MATERIALS AND METHODS

Fifteen varieties of sugarbeets were stored in 2 mil plastic bags at 5 and 25 C for 14 days. Each sample consisted of four roots with four replications per treatment. Extracts were prepared by immediately mixing 30 gms of well mixed brei from the brei saw with 50 ml of grinding media ( $5 \times 10^{-2}$  M  $\text{PO}_4$ ,  $1 \times 10^{-4}$  M Mercaptoethanol,  $1 \times 10^{-2}$  M  $\text{NaSO}_3$ ,  $1 \times 10^{-4}$  M EDTA, pH 7.5). The samples were stirred periodically over a 20 min period and then filtered through 4 layers of cheesecloth. The filtrate was centrifuged at 30,000 xg for 10 min and the soluble protein content of the supernatant was determined by the method of Lowry.

A second portion of the same brei sample was squeezed through muslin cloth and immediately frozen. The samples were later clarified by adding  $\text{CaO}$ , titrating to pH 9.2 with phosphoric acid and centrifuging. Sucrose was determined on the clarified sample by the method of Roe (1949) and amino acids by the method of Rosen (1957). Reducing sugars were removed prior to the determination of sucrose by adding  $\text{NaOH}$  to 0.5 M and heating for 15 min in a boiling water bath. Total protein was determined by the kjeldahl method on shredded root tissue dried 24 hours at 55 C.

### RESULTS AND DISCUSSION

The differences in total protein were not significant, due to a smaller number of samples and a large variation between samples (table 1). The soluble protein content increased in the 5 C storage but declined at 25 C. The amino acid content did not change at 25 C but decreased significant at 5 C.

The changes in amino acid content reflected the change in protein only at the 5 C storage temperature. Apparently at low storage temperatures, amino acid synthesis is slower than protein synthesis, thus depleting the free amino acid pool. Under conditions of protein degradation (warm storage), the amino acids released did not accumulate, but were readily metabolized probably via the TCA cycle.

Table 1. Protein and amino acid content of sugarbeets stored for 0 or 14 days at 5 or 25°C.

	Total Protein mg/gm FW	Soluble Protein mg/gm FW	Amino Acids mg/gm S
At harvest	5.16	3.35	20.0
After 14 days at:			
5 °C	4.60	3.95	11.1
25 °C	4.18	2.66	22.5
LSD .05	NS	0.43	5.8

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## Virus Investigations

David L. Mumford

### A New Method of Artificially Transmitting Curly Top Virus

Curly top virus (CTV) was artificially transmitted to sugarbeet by an injector instrument normally used in human mass immunization programs. The injector is used to introduce under high pressure a jet stream of beet juice containing CTV into the crown of the sugarbeet.

Plants of a susceptible sugarbeet cultivar (US 33) ranging in age from 27 to 77 days old were inoculated by a single injection into the crown of each plant as described above. Fifty percent infection was obtained when 48-day old plants were inoculated (table 2). The percentage infection decreased when younger plants down to 27-days old or older plants up to 77-days old were inoculated.

This method of virus transmission offers considerable advantage to the research worker over insect transmission when it is necessary to inoculate individual plants. Maintaining colonies of insects and transferring them during virus transmission requires much time, labor and facilities. Maintaining insect-free areas for inoculation and symptom development requires constant attention. These difficulties would be eliminated if artificial transmission of CTV could be used. In addition, this method may be applicable to other leafhopper-transmitted viruses, most of which have not been transmitted artificially.

In order to be of maximum value in assay procedures or in screening for host resistance, the percentage infection obtained from any inoculation method must approach 100 percent. Work is now in progress to investigate various ways of increasing the percentage infection using the injector method of artificially transmitting CTV.

### Isolates of Curly Top Virus and Yellow Vein Virus from the Pacific Northwest

Curly top of sugarbeet was very mild throughout the Pacific Northwest in 1971. Few fields were observed where curly top was severe enough to cause significant yield reductions. The virulence of 10 isolates of CTV collected from 3 states was compared in the greenhouse with isolate 66-10 from Utah. Table 2 presents the average grade obtained from testing each isolate on 20 resistant and 20 susceptible plants.

Isolate 66-10 was a full grade more virulent on the resistant test plants than any isolate collected. All isolates except 71-10 seemed to produce more severe symptoms on the resistant test plants than in previous years.

In 1970 a few plants with beet yellow-vein virus (BYVV) were found in the vicinity of Walla Walla, Washington. In 1971 beets with BYVV could be readily found in the vicinity of Mt. Home and Grandview, Idaho. Collections of this virus have been mechanically transmitted in the greenhouse. Attempts are being made to verify the relationship between this virus and its reported insect vector Aceratagallia calcaris Oman.

#### Field and Greenhouse Evaluations for Resistance to Curly Top Virus

A high level of infection was obtained in a curly top disease nursery of 1700 rows in 1971. A set of demonstration cultivars representing a wide range of reaction to CTV could be readily distinguished indicating good reliability in identifying resistant lines in the nursery.

A group of 87 lines from this nursery was also evaluated for resistance to CTV in the greenhouse. These lines were selected because of their wide range of reaction to CTV. A highly significant correlation coefficient of .78 was obtained between results of field and greenhouse evaluations. Eighteen of the 87 lines tested in the greenhouse received grades that were at least one full grade lower (more resistant) than the average of all greenhouse grades. None of these 18 lines received a grade in the field that was higher (more susceptible) than the average of all field grades. This determination adds support to the reliability of selecting for resistance to CTV in the greenhouse.

#### Evaluation of two Nematicide-Insecticides in Controlling the Sugarbeet Leafhopper

In cooperation with Dr. Gerald Griffin, Crops Research Laboratory, Logan, Utah, two nematicide-insecticides (aldicarb and carbofuran) were compared with the insecticide phorate currently being used for sugarbeet leafhopper control. Preliminary information indicated aldicarb could be applied with the seed. This material, therefore, was tested at rates of 1 and 2 pounds per acre (1bs/A) applied both with the seed and below the seed at a depth of approximately 3 inches. Carbofuran and phorate were tested only below the seed at 2 lbs/A.

Side-dress applications of all 3 chemicals were at 2 lbs/A and were applied 16 days after planting. Both below-seed and side-dress applications were accomplished by placing the chemical in a hand-opened furrow 3-4 inches deep. Seed was planted directly over the treated row at a depth of approximately 3/4 inch. Side-dress furrows were within 1-2 inches alongside the row of seedlings.

Four seedlings were randomly selected from the center 6 feet of each 12-foot plot. Two leafhoppers were caged on the youngest expanded

leaf of each plant every week. The number of dead leafhoppers was determined for 4 replications per treatment after 24, 48 and 72 hours each week.

Data were collected beginning the week after emergence and continuing for 4 weeks with treatments of aldicarb and 7 weeks with treatments of carbofuran and phorate. Data on side-dress applications were obtained beginning the third week after planting and continuing until the seventh week.

Half-way through the first experiment (planted May 27) two replications were lost to accidental flooding. The remaining two replications were continued and, in addition, on June 24 the entire experiment was replanted. Results from the 2 experiments are similar, so only the 24-hour data from the June planting are presented in table 3.

The below-seed applications of phorate and carbofuran gave, respectively, 100 and 88 percent kill of leafhoppers 40 days after planting. The below-seed application of aldicarb gave 100 percent kill of leafhoppers 19 days after planting, but by the 33rd day killed only 34 percent. With-seed applications of aldicarb lost effectiveness after 12 days. Side-dress treatments with all three chemicals were less effective in killing leafhoppers than below-seed treatments at planting. Maximum leafhopper kill occurred 16 days (24 days in the case of phorate) after application.

A natural infestation of flea-beetle permitted evaluation of the three chemicals used in these experiments in preventing injury by this insect. Light or no injury was observed on plants (2-6 leaf stage) treated with any of the three chemicals, whereas adjacent untreated checks had severe injury. Ratings assigned to plots with different treatments indicated below-seed treatments of all three chemicals were about equally effective in preventing injury..

Data presented here indicate that if aldicarb or carbofuran are used for nematode control they will also provide considerable control of the sugarbeet leafhopper and possibly other insects. The duration of leafhopper control based on a below-seed application of 2 lbs/A is approximately 3 weeks for aldicarb and 5 weeks for carbofuran.

Table 1. Effect of plant age in artificial transmission of curly top virus to sugarbeet.

Age of plant at inoculation (days)	Percentage infection - days after inoculation <sup>a/</sup>	
	18	28
27	19	29
34	30	30
41	25	42
48	38	50
56	25	38
63	21	33
70	17	25
77	13	21
Check	0	0

<sup>a/</sup> Twenty-four plants (cultivar US 33) were inoculated for each treatment

Table 2. Virulence of curly top isolates from the Pacific Northwest

Location	Identification No.	Grade <sup>a/</sup>	
		NB-1	3561
Mt. Home, Idaho	71-1	4.3	7.4
Grandview, Idaho	71-2	4.2	7.4
" "	71-3	3.8	6.7
Nampa, Idaho	71-4	3.9	6.5
Vale, Oregon	71-5	3.9	7.2
Big Bend, Oregon	71-6	3.5	6.1
Othello, Washington	71-7	4.0	6.9
" "	71-8	3.8	6.8
Quincy, Washington	71-9	4.3	7.4
Toppenish, Washington	71-10	1.6	6.1
Utah (standard)	66-10	5.3	7.5

<sup>a/</sup> Grades based on scale of 0-9 with 0 = no symptoms and 9 = dead. Grades given are averages from testing each isolate on 20 resistant (NB-1) and 20 susceptible (3561) plants.

Table 3. Percentages of leafhoppers killed within 24 hours after caging on treated sugarbeets.

Treatment	Rate 1b/A	Days after planting					
		12	19	26	33	40	47
Aldicarb with seed	1	94 <sup>a/</sup>	53	22	22		
	2	72	63	16	0		
Aldicarb below seed	1	78	63	19	3		
	2	94	100	53	34		
Carbofuran below seed	2	88	97	100	97	88	13
Phorate below seed	2	88	100	94	100	100	25
Aldicarb side dress	2	(side dress treatments applied 16 days after planting)		72	91	53	16
Carbofuran side dress	2			56	78	75	28
Phorate side dress	2			16	56	88	22
Check	0	19	3	3	3	15	3
							6

<sup>a/</sup> Percentages based on two leafhoppers caged on each of four plants in each of four replications per treatment.



## SUGARBEET RESEARCH

### 1971 Report

#### Section D

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SUMMARY OF ACCOMPLISHMENTS, 1971

1. Combining Ability and Gene Action Estimates in an Eight Parent Diallel Cross of Sugarbeet (G. A. Smith, R. J. Hecker, and D. M. Rasmussen). Combining ability and estimated components of genetic variance were determined for root weight, sucrose %, thin juice purity, recoverable sugar and root/shoot ratio. For root weight, non-additive genetic variance accounted for 58% and 72% of the total genetic variance under low and high nitrogen regimes respectively. For sucrose percent, additive genetic variance accounted for 76% and 70% of the total genetic variance under low and high nitrogen regimes respectively. For root/shoot ratio, over 90% of the total genetic variance was accounted for by the additive component under both high and low nitrogen levels. For recoverable sugar, non-additive genetic variance accounted for over 75% of the total genetic variance.

2. Effect of Factory Processing on Sugarbeet Juice Nitrogen Constituents, Including Individual Amino Acids (G. W. Maag). A study of the nitrogen components, including individual amino acids, in the factory sugarbeet processing juices. Analysis of factory sample from the diffusion juice stage through the standard liquor stage showed quantitative changes in several nitrogen components including some of the amino acids. Total nitrogen and amino nitrogen showed a decrease during processing; betaine remained basically the same. Glutamic acid, aspartic acid, glutamine, asparagine, glycine, tyrosine, alanine, methionine, leucine, histidine, and arginine were some of the amino acids and amides which showed quantitative changes during processing.

3. Effect of Storage Time and Temperatures on Sugarbeet Root Amino Acids and Other Nitrogen Components (G. W. Maag). Roots from two hybrid cultivars, one diploid and one triploid, were stored at two temperatures (36 and 51°F) for five storage periods (2 weeks, 1, 2, 3, and 4 months) at 96% relative humidity. Total nitrogen and betaine showed little change during the storage times in either cultivar. Ammonium nitrogen increased some, especially at the 51°F storage temperature. Some amino acids and the amides showed some changes with time; the 51°F temperature usually having the greater change effect. The amino acids affected most were aspartic, glutamic, proline, arginine, and gaba. Tyrosine was not found during early storage but formed, especially at 51°F, during the later storage periods.

4. Effect of Ethrel and Other Chemicals on the Induction of Pollen Sterility in Sugarbeet (R. J. Hecker and G. A. Smith). In an attempt to chemically induce male sterility in sugarbeet (Beta vulgaris L.), we conducted greenhouse and field experiments evaluating 2-chloroethylphosphonic acid (Ethrel), estrone, arsenic acid, and 2,3-dichloroisobutyrate (FW-450) as male gametocides. Various concentrations of these chemicals were applied on six different populations. Estrone induced a significant amount of pollen sterility in certain populations in particular environments, but the amount of emasculation was not sufficient or consistent enough to be of practical value. Arsenic acid was highly phytotoxic and had no gametocidal effect. Ethrel induced varying amounts of pollen sterility, dependent upon genotype. FW-450 effected the greatest amount of pollen sterility, but these and the experiments of others have shown it to be inadequate as a commercial gametocide. Ethrel at 200 ppm reduced seed yield drastically; it is doubtful that any sugarbeet genotypes will tolerate 1000 to 2000 ppm which was reported to emasculate wheat.

5. Rhizoctonia Resistance Field Research, 1971 (R. J. Hecker and E. G. Ruppel). Nine different field experiments were conducted in the 1971 Rhizoctonia nursery; results of five are reported separately. In experiment R-6 we showed that Rhizoctonia resistance in sugarbeet has increased with each advancing selection cycle. The differences were not always significant but the trend was toward improved resistance. The FC 701 and FC 702 series apparently have sufficient genetic variability to provide for improved resistance. Further selection is anticipated. Experiment R-7 evaluated progeny lines for resistance. Several progeny lines were identified that were suitable for advanced selection and breeding. Experiment R-8 tested 13 top-cross hybrids made with Rhizoctonia resistant pollinators. Only two of the 13 hybrids failed to show some degree of dominance for resistance. Experiment R-9 provided comparative diseased and healthy plant materials for initial studies on biochemical nature of Rhizoctonia resistance in sugarbeet.

6. Rhizoctonia Resistance Evaluation of Contributed Sugarbeet Lines, Experiment R-4, 1971 (E. G. Ruppel, R. J. Hecker, and J. O. Gaskill). Thirty-eight sugarbeet hybrids and breeding lines contributed from commercial and U.S.D.A. sources were evaluated for Rhizoctonia resistance. The FC 701 and FC 702 lines and their derivatives showed increased resistance with advancing generations of selection. In hybrids, resistance was partially dominant whenever the female was quite susceptible (disease index greater than 2.7).

7. Study of Environmental Variances Associated with Rhizoctonia Resistance (R. J. Hecker and E. G. Ruppel). A comparison of variances associated with Rhizoctonia infection in homogeneous and heterogeneous populations indicated that the variances of homogeneous populations cannot be used as direct measures of environmental variance. A log transformation improved the relationship of the variances but the improvement was not sufficient. It appears that in basic genetic and breeding studies of resistance to Rhizoctonia it will be necessary to estimate environmental variances by more complex methods.

8. Preliminary Study on Growth of Rhizoctonia on Leaf-Extract Media Prepared from Resistant and Susceptible Sugarbeets (E. G. Ruppel). Rhizoctonia solani grew significantly more on a leaf-extract medium prepared from a root-inoculated resistant cultivar (FC 701/2) than on media from noninoculated FC 701/2 beets, or inoculated and noninoculated susceptible GW 674-56C beets. Results tentatively suggest that a heat-stable substance(s) is present in leaf extracts of inoculated plants of FC 701/2 that inhibits growth of R. solani in culture.

9. Reaction of Root-Rot Resistant and Susceptible Sugarbeet Cultivars to Foliar-Blight Isolates of Rhizoctonia solani (E. G. Ruppel). Foliar isolates induced a minimal rot in wounded, but not unwounded, roots of resistant cultivar FC 701/2 and susceptible cultivar GW 674-56C. Foliar isolates, however, caused appreciable foliar blight in root-rot resistant cultivars FC 701/2 and FC 702/2, and in susceptible cultivars GW 674-56C and C 817. Significantly greater disease severity in FC 701/2 and FC 702/2 as compared to GW 674-56C and C 817 indicated that resistance of these lines to Rhizoctonia root rot may not be expressed against foliar blight.

10. Reaction of Five Sugarbeet Cultivars to Inoculation with Five Isolates of Rhizoctonia solani (E. G. Ruppel). Isolates were significantly different from each other in virulence, but their relative behavior was similar in all lines in the field. Results support previous studies in the greenhouse which indicated that resistance of lines selected at Fort Collins apparently is effective against several highly pathogenic isolates of R. solani.

11. Side Dress Versus Rosette Method of Inoculating Sugarbeets with Rhizoctonia solani in the Field (E. G. Ruppel and J. O. Gaskill). A technique of side-dressing 12 cc of dry, ground barley grain inoculum per 20-foot row 3 weeks after thinning was not significantly different from inoculation by the more tedious rosette method at 5 weeks after thinning for initiating a root rot epidemic in the field. Side-dress rates of 12 cc at 1 week, or of 24 cc at 1 and 3 weeks after thinning were too severe to permit adequate contrasts between resistant and susceptible cultivars.

12. Effect of Benomyl in Controlling Rot of Stored Sugar-beet Roots (E. G. Ruppel and J. O. Gaskill). Four rates of benomyl were ineffective as fungicide slurries in controlling storage rot of mother beets. There was a trend toward increased rot with an increase in benomyl concentration up to 1 lb/100 gal water.

13. The Association of Cercospora Leaf Spot, Gross Sugar, Percent Sucrose and Root Weight (G. A. Smith). Leaf spot readings, sucrose analyses, and root weight determinations were taken on 488 individual roots from three  $F_2$  populations segregating for leaf spot resistance. Each plant received a leaf spot rating of 1 to 9 with 1 being the most resistant. An increase in leaf spot severity from class 1 to 9 was paralleled by a 5 to 37% reduction in sucrose percent. For root weight, increased leaf spot from grade 1 to 9 was paralleled by a 14 to 42% reduction. For gross sugar per root, increased leaf spot from 1 to 9 was paralleled by an 11 to 64% reduction in gross sucrose.

Reduction in gross sucrose from high leaf spot (classes 7 through 9) were due more to reduction in root weight than to reduced sucrose percent whereas, reduction in gross sucrose from leaf spot classes 1 to 6 were due more to reduction in percent sucrose.

14. Sugarbeet Leaf Amino Acids and Their Relation to Cercospora Leaf Spot Resistance (G. W. Maag, D. M. Rasmussen, R. J. Hecker, and P. A. Whitaker). In an attempt to detect useful relationships of individual amino acids and Cercospora leaf spot resistance, 22 amino acids were quantitatively determined in infected and noninfected sugarbeet leaves harvested at three stages of infection. No obvious relationships were detected by examination of the means. A discriminant analysis was used which identified dopa and glutamic acid as the amino acids which maximized the information discriminating resistance in noninfected plants. In infected plants cystine, pipecolic acid, the serine-glutamine-asparagine combination, and lysine maximized the information and generated a different discriminant function. The function developed in noninfected plants was considered most discriminating, hence, potentially more useful for resistance classification of unknown populations. Now the decision will have to be made on the worth of a large empirical test evaluating the usefulness and efficiency of the discriminant function as means of resistance classification.

15. Cooperative Tests of LSR-CTR Varieties (G. A. Smith, E. G. Ruppel, R. J. Hecker, and Cooperators). Eight hybrid varieties, including a LSR check, a CTR check and six varieties having some resistance to both leaf spot and curly top (LSR-CTR) and including one entry with some Rhizoctonia resistance were evaluated by federal, state, and sugar company research personnel in several states in 1971. FC 903 as a pollinator with two different female lines (entries 3 and 4) performed especially well under leaf spot conditions. Average sucrose yields of entries 3 and 4 expressed as percentages of the standard variety (US H20, entry 1) were 110 and 107 respectively. Entry number 6 which featured FC 701/2 as a Rhizoctonia resistant pollinator was of special interest. Entry 6 showed the highest average sucrose percentage of all entries under leaf spot conditions and under leaf spot free conditions. Consistency of performance for percent sucrose over the environments was shown with the only poor performance seen at the Beltsville, Maryland location.

16. Cercospora Leaf Spot as a Predisposing Factor in Storage Rot of Sugarbeet Roots (G. A. Smith and E. G. Ruppel). The number of rotted beets in samples selected for low leaf-spot resistance in two segregating  $F_2$  populations was 2 or 3 times larger than the number of rotted beets in samples selected for high resistance. The degree of field leaf-spot infection closely paralleled the number of harvested roots that rotted in storage.

17. Transfer of Cercospora beticola resistance from Beta procumbens to Beta vulgaris (G. A. Smith). Resistant plants were selected under field leaf spot conditions from segregating populations of Beta procumbens x Beta vulgaris crosses. Selections were split into sugarbeet type and procumbens type and polycrossed within groups. Polycrossed seed harvested from a total of 112 plants from the two groups will be tested under field leaf spot conditions in 1972.

## COMBINING ABILITY AND GENE ACTION ESTIMATES IN AN EIGHT PARENT DIALLEL CROSS OF SUGARBEET

G. A. Smith, R. J. Hecker, and D. M. Rasmuson

The diallel cross has proved to be of considerable value to plant breeders in making decisions concerning the type of breeding system to use and in selecting breeding materials that show the greatest promise for success. It has also been used successfully by quantitative geneticists to gain a better understanding of the nature of gene action involved in determining quantitative traits. Diallels have been used primarily to estimate genetic variances when parents are either random individuals or inbred lines from a random-mating population in linkage equilibrium, and to estimate general and specific combining ability effects from crosses of a fixed set of lines.

The purposes of the study reported here were to: (a) ascertain the relative importance of general and specific combining ability for sucrose percent, root weight, purity, recoverable sugar, and root/shoot ratio; (b) obtain estimates of the magnitude of genetic variances for additive and non-additive gene action; (c) determine the effect of nitrogen fertility levels on gene action.

### Materials and Methods

Eight highly inbred lines were crossed to give all 28 possible single crosses, excluding reciprocals. These inbred lines were a random set with a wide range of variation for the five characters studied. The only criterion for choosing the inbred lines for this study was that they had matching cytoplasmic male sterile (CMS) equivalents. Crosses were made in 1.8m x 1.8m x 1.8m isolation chambers in the greenhouse. Three or four of the CMS inbred lines were placed in each isolation chamber with one male fertile line. Eight such isolations were utilized to obtain all possible single crosses. Synchronization of flowering of male and female lines was achieved by "slowing plants down" in photothermal induction chambers at 3.9C.

The field experiment consisted of four replications of  $F_1$ 's and the parental inbreds at each of two nitrogen fertility levels. Prior to planting, soil tests were taken in a 10 acre field to locate areas of high residual nitrogen. Four replications of the experiment were planted in the area with the lowest residual (nitrate N = 20 lbs/acre) nitrogen and received no nitrogen fertilizer. The other four replications of the experiment were planted on the high residual nitrogen portion of the field (nitrate N = 32 lbs/acre) and received a split application of 250 pounds of actual N as ammonium nitrate.

The single crosses and inbred parents were planted in single-row plots 6.1 m long bordered on each side by a medium vigor common competitor row. Rows were spaced 56 cm apart. The experimental design was a randomized complete block. At harvest, root weight (kg per plot), sucrose %, thin juice purity %, recoverable sugar (kg per plot), and fresh top weight (kg per plot) were determined. Ratio of root to shoot weight was determined and analyzed.

Analyses of variance were performed for each of the traits. The 28 single crosses of the diallel were analyzed using Griffing's (1) Method 4, Model II. Model II was considered appropriate because of the random nature by which the inbred lines were chosen. In Model II the assumption is that the diallel parents were a random sample from some general population, and inferences are not to be made about the individual parents in the sample, but rather, about the parameters of the general population. Because Model II was used, and because the parental inbreds in these hybrid combinations have no direct commercial value, a description of the inbred lines is not included in this report.

Estimates of the general combining ability (GCA) and specific combining ability (SCA) variance components and their standard deviations were calculated for the five traits measured.

#### Results and Discussion

The means and ranges for parental inbreds and  $F_1$  hybrids are presented in Table 1. There were significant differences between high and low nitrogen levels for all five characters for the  $F_1$  hybrids as a group, and for the parental inbreds for all characters except recoverable sugar (Table 2). Significant differences were found among parental inbreds and among  $F_1$  hybrids for all characters except thin juice purity %. The significant differences among parental inbred lines substantiated the expected genetic diversity of the lines. The parental genotype x nitrogen fertility interaction (NXP) was significant for all characters except percent purity, whereas, the  $F_1$  hybrid x nitrogen fertility interaction (NXF<sub>1</sub>) was significant for only root/shoot ratio and recoverable sugar. The root/shoot ratio interaction was found to be due to the interaction of top weight and N level rather than to a root weight x N level interaction. The lack of genotype x environment interaction in the  $F_1$  hybrids for other characters was likely the result of increased stability due to heterozygosity.

The general combining ability (GCA) and specific combining ability (SCA) mean squares calculated from the  $F_1$  hybrids using Griffing's Method 4 and Model II are shown in Table 3. SCA was significant for all characters at both nitrogen fertility levels. GCA was significant

at the low nitrogen level for root weight, sucrose percent, and root/shoot ratio. Under high nitrogen GCA was significant for sucrose percent, root/shoot ratio, and percent purity. General and specific combining ability are generally attributed to additive and non-additive gene action, respectively. As indicated in Table 3, additive as well as non-additive gene action were important in determining all characters except recoverable sugar. Non-additive gene action was most important in controlling recoverable sugar at both nitrogen fertility levels. The GCA mean square for root weight was non-significant at the high nitrogen level indicating that straight selection in segregating populations for root weight would not be effective under high nitrogen conditions. Conversely, for purity the GCA was not significant under low nitrogen but was significant under high nitrogen.

Relationships among mean squares only provide estimates of the relative total contributions of the sources of variance in the present experiment and consequently are not themselves directly comparable. Estimates of the GCA and SCA components of variance permit direct comparisons and are, therefore, more informative than F ratios in assessing the relative importance of additive and non-additive gene effects.

Estimates of variance components for specific and general combining ability are given in Table 4. Appropriate reservations should be applied in interpreting these estimates because their standard deviations were large in some cases. Where the SCA or GCA mean squares were not significant (Table 3) the corresponding SCA or GCA component of variance (Table 4) should be considered non-significant and will always have a high standard deviation. For root weight, comparison of additive (GCA) and non-additive (SCA) estimated variance components (Table 4) indicated that the estimated SCA variance component was larger than the GCA component under low and high nitrogen environments. Non-additive genetic variance accounted for 58% and 70% of the total genetic variance under low and high nitrogen environments, respectively. The estimated GCA variance components for sucrose percent and for root/shoot ratio were considerable larger than the SCA component under both nitrogen environments. For sucrose percent, additive genetic variance accounted for 76% and 69% of the total genetic variance under low and high nitrogen, respectively. For root/shoot ratio, over 90% of the total genetic variance was accounted for by the additive component under both high and low nitrogen. Thus, non-additive gene action appeared more important than additive gene action in determining root weight and recoverable sugar, but sucrose percent and root/shoot ratio differences were determined more by additive than by non-additive gene action.

The fact that 24-30% of the total genetic variance for sucrose content was attributable to non-additive genetic variance does not

agree with earlier reports of little or no dominance (3), or with a "general belief that sucrose content is conditioned by additive factors with no expression of heterosis or dominance" (4). The top-cross test, which has been so universally used by sugarbeet researchers, is really a test for general combining ability. Consequently, it is not surprising that high estimates for general combining ability (additive gene action) have been obtained for sucrose. The diallel analysis, on the other hand, is specifically designed to account for both general and specific combining ability. For root yield, our results emphasize the importance of non-additive genetic variance and consequently would not agree with the general conclusion of Helmerick et al. (2) who concluded that additive effects were much more important than non-additive effects for both root weight and sucrose. The fact that the lines used in our crosses were randomly selected and highly inbred could in itself account for some of the differences between our results and the results of others. In most other reports the lines used were selected for breeding purposes (non-random) and, hence, might be expected to give biased estimates of gene action.

For purity, the GCA mean square was not significant while the SCA mean square was significant under the low nitrogen level. Both GCA and SCA mean squares were significant under high nitrogen with the GCA component being slightly larger than the SCA component. Percent purity then appears to be a character which would be best improved under a breeding system which is designed to capitalize on both additive and non-additive gene action (e.g. reciprocal recurrent selection) under an intermediate nitrogen fertility level.

The data presented in this study may provide a more reliable guide for expectation under a system of recurrent selection for specific combining ability than for recurrent selection for general combining ability or reciprocal recurrent selection. Our results should apply to sugarbeet in general and should not be biased by selected lines. In general our results emphasize the importance of the non-additive component of genetic variance for several important sugarbeet characters. The significance of over 24 percent of the total genetic variance for sucrose percent being of the non-additive type becomes clear if one assumes that at least part of this total is non-epistatic. Most sugarbeet researchers would agree that an apparent plateau for sucrose percent has been reached. If this is true, then efforts to capitalize on all types of genetic variation, including the non-additive portion, must be pursued to increase sucrose percentage. The importance of nitrogen fertility level, which is such a common variable confronting the sugarbeet breeder, is emphasized by our results. These results indicate that particular attention should be given to nitrogen fertility level when the goal is improving thin juice purity percent or root weight.

An expanded report of this research is being prepared for journal publication.

Table 1. Group means for root weight, sucrose percent, purity percent, recoverable sugar and root/shoot ratio at two nitrogen fertility levels.

Entries	LOW NITROGEN				HIGH NITROGEN			
	Root <sub>2</sub> / wt. <sub>1</sub>	Sucrose %	Purity %	Recov. sugar	Root/ shoot	Root/ wt.	Sucrose %	Purity %
Single Crosses (F <sub>1</sub> 's)	12.85	15.81	94.38	1.78	1.77	16.06	11.14	89.67
Range	9.83-18.28	14.20-17.30	90.90-96.84	1.39-2.13	.89-2.51	13.08-19.95	9.68-12.38	87.23-93.47
S.E. of mean <sup>1/</sup>	.757	.365	.919	.111		.740	.327	.698
Inbred Parental Lines	6.34	15.51	94.30	.85	1.93	9.11	11.39	90.08
Range	2.40-7.80	13.85-17.13	91.66-96.16	.36-1.04	.69-2.88	6.3-13.43	10.00-12.20	87.86-93.25
S.E. of mean	.532	.334	.711	.069	.178	.859	.277	.873

<sup>1/</sup> S.E. of mean calculated as  $\sqrt{s_e^2/n}$ ; where  $s_e^2$  is the replication  $\times$  entry interaction and  $n$  is the number of observations comprising each mean.

<sup>2/</sup> Root weight as kilograms determined on plots 6.1 meters long.

Table 2. Analyses of variance (ANOVA) of five sugarbeet characters from diallel cross  $F_1$ 's and parental inbreds grown at high and low nitrogen levels.<sup>1/</sup>

Variance source	d.f.	Rt.wt.	Sucrose %	Root/shoot ratio	Purity %	Recoverable sugar
<u><math>F_1</math> ANOV</u>						
Nitrogen levels (N)	1	**	**	**	**	**
$F_1$ hybrids ( $F_1$ )	27	**	**	**	NS	**
$N \times F_1$	27	NS	NS	**	NS	*
<u>Parental ANOV</u>						
Nitrogen levels (N)	1	**	**	**	*	NS
Parental inbreds (P)	7	*	*	**	NS	**
$N \times P$	7	*	*	**	NS	**

<sup>1/</sup> \*, \*\* = significant at the 5% and 1% level, respectively.

NS = non-significant

Table 3. Mean squares from the combining ability analyses for five sugarbeet traits at high and low nitrogen levels.<sup>1/</sup>

Source	d.f.	Rt.wt.	Sucrose %	Root/shoot ratio	Purity %	Recoverable sugar
<u>LOW NITROGEN</u>						
GCA <sup>2/</sup>	7	6.52*	1.69**	.72**	2.51 <sup>NS</sup>	.06 <sup>NS</sup>
SCA	20	2.09**	.16**	.02**	1.22**	.03**
<u>HIGH NITROGEN</u>						
GCA	7	5.92 <sup>NS</sup>	1.17**	.22**	5.41**	.04 <sup>NS</sup>
SCA	20	2.78**	.15**	.10**	1.05**	.02**

<sup>1/</sup> \*, \*\* = significant at the 5% and 1% level, respectively.

NS = non-significant

<sup>2/</sup> GCA = general combining ability; SCA = specific combining ability.

Table 4. Estimates of general and specific combining ability variance components (with standard deviations) for five sugarbeet characters at high and low nitrogen levels.

Character	ESTIMATED VARIANCE COMPONENTS <sup>1/</sup>			
	Low Nitrogen		High Nitrogen	
	GCA	SCA	GCA	SCA
Root Weight	1.48 ± 1.18*	2.06 ± .66**	1.58 ± 1.55 <sup>NS</sup>	3.63 ± 1.16**
% Sucrose	.51 ± .30**	.16 ± .05**	.34 ± .21**	.15 ± .05**
Root/Shoot Ratio	.23 ± .13**	.02 ± .005*	.07 ± .04**	.008 ± .003**
% Purity	.43 ± .46 <sup>NS</sup>	1.17 ± .38**	1.45 ± .97**	1.03 ± .33**
Recoverable sugar	.01 ± .01 <sup>NS</sup>	.03 ± .01**	.004 ± .007 <sup>NS</sup>	.02 ± .007**

<sup>1/</sup> \*,\*\* = mean squares were significant at the 5 and 1% level, respectively.  
NS = non-significant.

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## EFFECT OF FACTORY PROCESSING ON SUGARBEET JUICE NITROGEN CONSTITUENTS, INCLUDING INDIVIDUAL AMINO ACIDS

G. W. Maag

This was a cooperative study with Mr. P. C. Hanzas (deceased), Manager Chemical Research, American Crystal Sugar Company, Rocky Ford, Colorado. I wish also to thank Mr. J. K. Hobbis, present manager Chemical Research, American Crystal Sugar Company, for his assistance.

The purpose of this study was to determine the effect of factory processing on the nitrogen constituents, including individual amino acids and amides, in sugarbeet juices.

### Materials and Methods

Factory juices were collected March 6, 1971, at the American Crystal Sugar Company factory at Clarksburg, California on day one of normal factory operation. The diffusion juice sample was collected, after which first (Dorr Clarifier overflow) and second carbonation, thin and thick juices, and standard liquor samples were collected. Sampling time was coordinated with the time that the sampled diffusion juice was to be at each processing stage. After laboratory readings were taken each sample was quick frozen. Later, the samples were packed in dry ice and transported, via air and car, to the Crops Research Laboratory, Fort Collins, Colorado, where they were stored at -20°F until analysis.

The types of factory juice samples, time of collection, and the brix, and pH readings of each sample were:

Type of sample	Time of collection	Brix (RDS)	pH
Diffusion juice	1:30 pm	13.2	6.0
1st carbonation juice	4:00 pm	13.0	11.0
2nd carbonation juice	4:10 pm	13.2	9.0
Thin juice	4:30 pm	13.1	8.8
Thick juice	5:30 pm	60.3	8.9
Standard liquor	5:45 pm	63.9	8.8

Duplicate samples, of each factory processing juice, were analyzed for total nitrogen (N), amino N, nitrate N, and betaine N and reported in mg per 100 ml sample, RDS 100. Individual amino acids, amides, and ammonia were determined using a Technicon Amino Acid Analyzer and reported in micromoles per 100 ml sample ( $\mu$ M/100 ml), RDS 100. The ammonium N was calculated later in mg/100 ml, RDS 100.

The factory juice samples were analyzed a second time by automated analysis, after basic hydrolysis in our laboratory, to determine the quantity of the amides, glutamine and asparagine, and of pyrrolidone carboxylic acid (PCA), the deamidation product of glutamine.

#### Results and Discussion

The total N, amino N, ammonium N, nitrate N, and betaine N determination results are given below in mg/100 ml sample, RDS 100:

N Constituent	Diffusion juice	1st carb. juice	2nd carb. juice	Thin juice	Thick juice	Standard liquor
Total N	576.8	504.4	496.8	467.8	534.0	405.1
Amino N	200.0	164.6	163.6	157.8	137.2	95.0
Ammonium N	12.1	38.5	42.4	40.3	2.8	7.5
Nitrate N	71.8	64.3	62.3	58.6	79.6	56.5
Betaine N	170.5	170.6	170.9	169.5	201.7	152.9

Total N decreased quantitatively in the juices during the factory processing. The largest decrease was between the diffusion juice and the first carbonation juice. This decrease in total N was probably due to loss of ammonia gas from the warm alkaline solution during the liming and carbonation process. During the factory processing, asparagine and glutamine were hydrolyzed partially to their respective amino acids with the release of ammonia. Glutamine, to a greater extent, changed to PCA, also with the release of ammonia. Some of the ammonia remained in the juices as the ammonium ion, but some escaped as ammonia gas.

The amino N, determined by a modified Moore and Stein method, also showed a decrease during processing. This was due mainly to the deamidation of glutamine to PCA. Only the  $\alpha$ -amino N in amino acids and amides is ninhydrin positive, therefore, the amide N in glutamine and asparagine, which produced the ammonia upon hydrolysis, was not included in the amino N determination. When glutamine hydrolyzed to PCA, the  $\alpha$ -amino N became bound in the pyrrole ring and, therefore, it was no longer ninhydrin positive even though it was still present in the molecule. In a mixture of only amino acids and amides the total N quantity would be greater than the amino N quantity because of the amide N present. Also, some amino acids contain N other than the  $\alpha$ -amino N, which also is not measured in the amino N determination. This is true of the basic amino acids such as lysine, histidine, tryptophan, and arginine.

Ammonia N showed a large increase in the first and second carbonation and thin juices. This, of course, was due mainly to the

hydrolysis of the amides and to the ammonia which was retained in solution as the ammonium ion. Some ammonia possibly was formed, also, in the warm basic solution, from hydrolysis of amines and the nitrogenous bases, choline and allantoin, which are present in minor quantities in sugarbeet juices.

Nitrate N showed some decrease in the processing of the diffusion juice to the carbonation juices. This may have been due to some bacterial action during the time period involved between collection of the diffusion juice and the processing to the carbonation juices.

Betaine remained basically the same throughout the processing, as we would expect.

Why some N components showed an increase in the thick juice stage, when all calculations were made to RDS 100, I cannot explain. Sodium and potassium were determined on these samples also and they showed an almost identical degree of increase in the thick juice.

Twenty-one amino acids and amides, plus ammonia, were measured quantitatively from the AutoAnalyzer analysis (shown in Table 1). Also present were several unidentified amino acids or ninhydrin positive analogs. Since the time of this analysis, we have identified some unknowns as  $\alpha$ -amino adipic acid, pipecolic acid,  $\alpha$ -amino-N-butyric acid,  $\alpha$ -amino-isobutyric acid, and possibly isovaline. Homoserine, sarcosine, and citrulline, also identified by us, were found only in the laboratory hydrolyzed juices. Some other unknowns are still unidentified. In previous work, we have found cystine in laboratory phosphated thin juice, but we found none in the Clarksburg juice samples. We found 3,4-dihydroxyphenylalanine (Dopa) in the diffusion juice only.

The serine, glutamine, asparagine combination was measured together in the factory juices because they eluted on the chromatograms as occluded peaks. Serine was used as the standard. Previous work in our laboratory had shown an approximate ratio of serine: glutamine:asparagine to be 1:3:0.5 in phosphated thin juice, however, this can vary with type of juice, genotype, N fertility, and growth conditions. Since the ninhydrin color factor is different for serine and the two amides, the micromoles of the combination can be considered only an estimation of the combination of the three. After the laboratory basic hydrolysis, the glutamine and PCA had hydrolyzed to glutamic acid and the asparagine to aspartic acid. Therefore, after hydrolysis, the serine value is serine alone; the glutamic acid value represents the original glutamic acid plus that converted from PCA and glutamine; and the aspartic acid value represents the original aspartic acid plus that converted from asparagine (Table 1).

Table 1. Amino acids and ammonia in Clarksburg, California factory processing juice samples, before and after laboratory basic hydrolyzation ( $\mu\text{M}/100 \text{ ml}$ , RDS 100).

Amino Acids	Clarksburg Factory Juice Samples						Hydrolyzed Clarksburg Factory Juice Samples					
	1st Diffusion juice		2nd Carb. juice		Thin juice		Standard liquor		1st Diffusion juice		2nd Carb. juice	
	Carb. juice	Carb. juice	Carb. juice	juice	juice	juice	juice	juice	Carb. juice	Carb. juice	Thin juice	Thick juice
1. ASP <sup>1/</sup>	900.9	707.7	755.2	796.5	899.8	672.9	1719.4	1577.8	1343.6	1313.9	1232.8	796.6
2. THR <sup>2/</sup>	140.8	155.7	168.8	173.1	241.8	145.8	137.3	111.2	113.0	113.6	109.8	67.9
3. SER <sup>2/</sup>	3565.8	1768.0	1677.0	1593.9	1527.4	809.7	797.3	621.5	645.2	633.6	601.6	419.7
4. GLU	723.3	872.9	1004.8	1067.0	1196.0	821.0	5446.3/	5596.0	5707.6	5432.1	4808.3	2541.2
5. PRO	292.1	229.8	237.3	236.9	252.0	174.6	3/	occ.	occ.	occ.	occ.	136.5
6. GLY	93.0	172.9	181.2	191.4	208.0	210.5	338.5	511.4	272.1	282.7	466.5	357.0
7. ALA	556.1	435.1	483.6	449.2	542.8	478.2	535.4	436.6	456.7	454.0	517.3	465.9
8. VAL	170.9	184.9	178.2	171.9	209.4	166.2	180.3	161.2	157.3	157.9	159.4	134.5
9. CYS	none	none	none	none	none	none	none	none	none	none	none	none
10. MET	57.9	44.3	38.8	30.8	35.2	38.7	45.8	39.7	39.1	32.7	23.2	19.6
11. ILE	227.0	224.0	218.5	200.0	244.6	204.9	204.8	197.2	190.9	184.4	190.6	155.6
12. LEU	241.8	230.5	226.7	199.1	244.4	216.5	214.8	178.2	185.2	178.3	181.0	143.7
13. DOPA	27.9	none	none	none	none	none	none	none	none	none	none	none
14. TYR	124.2	347.7	372.7	315.1	371.0	291.0	110.9	283.1	290.9	280.6	283.1	219.2
15. PHE	34.2	35.4	35.4	28.7	25.3	22.7	30.9	29.5	33.0	28.7	15.9	8.3
16. NH <sub>3</sub>	867.0	2736.9	3027.0	2879.4	201.8	533.5	1989.1	1378.2	1485.8	1956.6	809.7	622.5
17. GABA	1654.8	1198.5	1259.4	1062.0	1158.3	984.8	1233.9	1007.1	989.4	979.8	840.3	626.0
18. ORN	2.0	2.0	2.0	2.0	2.0	2.0	10.0	8.3	10.9	9.8	3.9	2.6
19. LYS	29.7	24.9	25.8	22.9	25.6	22.9	28.5	20.6	19.4	19.5	15.8	11.6
20. HIS	55.4	28.6	25.8	22.6	26.7	21.8	4.0	4.0	4.0	4.0	5.4	6.3
21. TRY	73.0	60.3	60.9	50.1	65.3	53.6	70.6	56.0	55.2	42.4	52.6	40.2
22. ARG	62.4	8.9	13.6	12.5	15.1	10.1	none	none	none	none	none	none

1/

1. aspartic 2. threonine 3. serine 4. glutamic 5. proline 6. glycine 7. alanine 8. valine 9. cystine  
10. methionine 11. isoleucine 12. leucine 13. 3,4-dihydroxyphenylalanine 14. tyrosine 15. phenylalanine  
16. ammonia 17. gamma-aminobutyric acid 18. ornithine 19. lysine 20. histidine 21. tryptophan 22. arginine

2/

Determined as a combination of serine, glutamine, and asparagine in original juice because of occluded peaks.  
After basic hydrolysis, serine is measured alone.

3/ Occluded peaks.

Comparison of relative amounts of aspartic acid, glutamic acid, and serine in the factory juices, before and after laboratory basic hydrolysis, emphasized the important role of the amides in the sugar-beet juices. The amount of aspartic acid almost doubled after basic hydrolysis due to the asparagine deamidation. The glutamic acid increased by over seven times in the diffusion juice after hydrolysis, by over six times in the first carbonation juice, by almost six times in the second carbonation juice, and by over five times in the thin juice. The ratio of increase went down some with each processing step because some of the glutamine was hydrolyzed to glutamic acid during the factory juice processing. The serine, glutamine, asparagine combination decreased, after the basic hydrolysis, since only serine remained.

Glycine and tyrosine increased considerably between the diffusion and first carbonation juices, and each showed small increases later. Most other amino acid quantities remained essentially the same through the processing except for alanine, methionine, leucine, histidine and arginine. All of which showed some decrease during processing. Dopa was present only in the diffusion juice; possibly it changed to dopamine or to a quinone during processing. Arginine possibly hydrolyzed to citrulline or to ornithine. Ornithine was present in trace quantities in all juices, before basic hydrolysis, but was present in somewhat larger quantities in the hydrolyzed juices. Citrulline was also present in the hydrolyzed juices.

#### Summary

Many nitrogen components are affected by the factory processing. It has long been known that glutamine, present in relatively large quantities in sugarbeet juices, undergoes important changes during processing, as does asparagine. Some other amino acids such as glycine, tyrosine, alanine, methionine, leucine, histidine, and arginine also apparently undergo changes during the processing which may have an overall important effect on the sucrose purification and crystallization processes.

This was a preliminary study only. Before specific conclusions can be assessed concerning the effect of processing on the nitrogen components, a much more complete study, involving many factory samplings, should be made.

EFFECT OF STORAGE TIME AND TEMPERATURES  
ON SUGARBEET ROOT AMINO ACIDS AND OTHER NITROGEN COMPONENTS

G. W. Maag

This was a cooperative experiment with Mr. P. C. Hanzas (deceased), former Manager Chemical Research, American Crystal Sugar Company. I also wish to thank Mr. J. K. Hobbis, Manager Chemical Research, American Crystal Sugar Company, Rocky Ford, Colorado, for his assistance in this study.

This experiment was designed to study the effect, if any, of different storage times and temperatures on sugarbeet root amino acids and other nitrogen constituents.

Materials and Methods

The two sugarbeet cultivars, selected for this study, were grown on American Crystal Sugar Company test plots at East Grand Forks, Minnesota, during the summer of 1970. Cultivar A was American 2, hybrid B, diploid; cultivar D was American 3, hybrid T, triploid. Both were grown under normal fertilization and moisture conditions.

The sugarbeets were harvested in the fall with minimal hand topping, and stored, with no additional cleaning, in a sheltered storage area at 40 to 55°F for 8 days. They were transported by truck (1.5 days) to Rocky Ford, Colorado, and stored 5.5 days at 36°F and 96% humidity. At the end of the 15 day post-harvest period, the beets were sorted by size into three groups, from which three large, four medium, and four small beets were selected. This was done to prevent root size from being a factor in the experiment. Each sample was placed in a perforated plastic bag and weighed. The experiment was a factorial with two varieties, two storage temperatures (36 and 51°F), five storage periods (2 weeks, 1, 2, 3, and 4 months), plus 32 control samples. The relative humidity in storage was 96%.

The 16 control samples of each cultivar, were washed and brei from each sample was prepared with a Spreckels saw. Pressed juice was obtained by hand squeezing a muslin bag containing the well mixed brei. After laboratory readings were taken on the pressed juice, it was quick frozen and stored. No preservative was added.

At the end of each storage period of 2 weeks, and 1, 2, 3, and 4 months, eight replicate samples of each cultivar at each storage temperature, were removed from storage, weighed to determine shrinkage, washed, and brei and pressed juice were prepared as before.

The direct polarization sucrose readings, taken on each sample, were later corrected for shrinkage. The pressed juice samples were frozen and stored.

Storage time	CULTIVAR A				CULTIVAR D			
	36°F		51°F		36°F		51°F	
	% Shrink	Corr. Dir. Pol.	% Shrink	Corr. Dir. Pol.	% Shrink	Corr. Dir. Pol.	% Shrink	Corr. Dir. Pol.
0 (control)	0.0	16.0	0.0	16.0	0.0	16.4	0.0	16.4
2 weeks	0.7	17.4	1.8	15.6	0.8	16.4	2.2	16.9
1 month	1.0	15.7	3.3	15.4	1.4	16.9	3.5	16.3
2 months	2.0	16.2	5.3	15.2	2.8	16.4	6.1	15.9
3 months	1.8	15.1	8.0	14.1	3.0	16.3	13.8	14.1
4 months	2.8	15.3	10.0	12.5	3.1	16.2	21.2	12.3

Means for the % shrinkage and corrected direct polarization readings for the 16 control samples and for each group of eight stored samples for each cultivar at the different storage times and temperatures are given in the accompanying text tabulation.

Cultivar A, at 36°F, showed a sucrose loss of 20 pounds per ton of sugarbeets after four months storage, while, at 51°F, the loss was 72 pounds of sucrose per ton of beets. During the same period of time, cultivar D showed a loss of 6 pounds of sucrose per ton at 36°F and 80 pounds of sucrose per ton at 51°F.

The frozen pressed juice samples were packed in dry ice and delivered to Fort Collins, Colorado. After thawing, composite samples were prepared of each set of eight replicates of each cultivar, including controls, by measuring and combining equal volumes of each sample. This was done because of the time involved for each automated amino acid analysis. Each composite sample was deproteinized and clarified with sulfosalicylic acid (0.1 g per ml) and centrifuged before analysis.

Duplicate composite samples were analyzed for total nitrogen (N), amino N, and betaine N. Nitrate N was to be determined using an Orion Specific Ion Meter with a nitrate ion activity electrode, but the sulfosalicylic acid interfered with the determination, giving extremely high readings. Individual amino acids, amides, and ammonia were determined in micromoles using a Technicon Amino Acid Analyzer. The ammonia was calculated later as ammonium N. All analytical results were calculated to mg per 100 ml pressed juice at a refractive dry substance of 100 (mg/100 ml, RDS 100).

### Results and Discussion

The analytic results for total N, amino N, betaine N, and ammonium N for pressed juice samples of cultivars A and D are given in the accompanying table in mg N per 100 ml, RDS 100. Included are the means for the two groups of eight replicate control samples, plus the duplicate sample means for each storage treatment.

Storage time	Temp (F°)	Cultivar A				Cultivar D			
		Total N	Amino N	Betaine N	NH <sub>4</sub> N	Total N	Amino N	Betaine N	NH <sub>4</sub> N
0 (control)		577.1	247.5	144.5	20.3	672.1	286.7	176.5	19.7
2 weeks	36°	596.7	269.2	142.4	23.1	698.1	254.7	163.6	18.2
	51	623.8	262.4	144.3	19.2	652.4	268.4	162.8	18.8
1 month	36	586.5	249.2	139.9	19.0	656.8	235.6	162.6	16.0
	51	630.0	282.7	146.3	21.4	636.2	263.0	162.4	18.3
2 months	36	605.8	247.5	141.7	17.6	641.3	244.6	161.4	17.6
	51	599.5	259.7	147.2	19.1	654.4	265.7	166.4	19.8
3 months	36	603.5	245.9	140.4	16.9	645.2	247.0	166.0	15.6
	51	591.6	260.5	152.2	23.7	692.0	293.1	191.8	21.7
4 months	36	593.1	277.3	142.9	14.4	659.1	270.7	193.2	16.5
	51	621.0	273.0	159.4	23.1	706.3	308.2	218.0	24.1

The results from the statistical analysis of this data is not yet available, therefore, the discussion of the data in this report is based upon observations only.

The total N,  $\alpha$ -amino N, betaine N, and ammonium N ( $\text{NH}_4\text{-N}$ ), in both cultivars, showed relatively small variations between storage times and temperatures. Some of the variation, for each cultivar, may have been due to differences in the samples, rather than due to the storage time or temperature effect. Some differences, especially at the 51°F storage temperature, may have been due also to shrinkage effect, although most of that should have been counter-balanced when all results were calculated to the same RDS.

There appeared to have been some significant differences between the two cultivars, especially in total N and betaine N. Cultivar D, the American 3, hybrid T, triploid, stored at 51°F, ranked highest in all the N components after the second storage month. It also ranked highest in all except ammonium N, in the control samples. Both cultivars showed more increase in ammonium N during the last two months at the higher storage temperature. This was possibly due to more deamidation of the amides at the higher temperature.

Automated analysis of the composite pressed juice samples resulted in quantitative determination of twenty-five amino acids and amides, plus ammonia. (Tables 1 and 2). The amides, glutamine and asparagine, were determined in combination with serine because the three peaks eluted on the chromatograms as occluded peaks. The occluded peak area was calculated using serine as the standard, since serine was the amino acid included in the Technicon Amino Acid standard solution which eluted in that area of the chromatogram. Previous work in our laboratory on sugar-beet juice samples showed the approximate ratio of serine:glutamine:asparagine to be 1:3:0.5, however, this can vary with type of sugar-beet juice sample, genotype, N fertility, and growth conditions. This ratio was used, with respective formula weights, to convert from micromoles of serine to mg of the serine, glutamine, asparagine combination. Difference in the ninhydrine color factor, among the three, also may effect the results to some extent, but this does give quantitative amounts for comparison.

Several unknown amino acid or amino acid analog peaks were produced on the chromatograms also. Some amino acids were present only in minor quantities such as sarcosine, homoserine, citrulline, pipecolic acid,  $\alpha$ -amino-n-butyric acid,  $\alpha$ -amino-isobutyric acid, and ornithine. Dopa (3,4-dihydroxyphenylalanine) was found only in cultivar D after 2 months of storage, with slightly more at the 51°F storage temperature than at 36°F. No tyrosine was present in cultivar A control samples, and measurable amounts were not present in the stored samples up to 2 months of storage time. Cultivar D did have a trace amount in the control samples, then it became measurable in the 1 month storage samples and increased as storage time lengthened, especially at the 51°F temperature.

Even though the  $\alpha$ -amino N showed relatively little change with storage temperature and time for either cultivar, some individual amino acids did appear to show significant changes.

Amino acids can be involved in chemical changes in many different ways. Some of the possible changes may be:

1. Degradation of peptide molecules to produce amino acids. The sulfosalicylic acid was used to precipitate the larger polypeptide and protein molecules in these samples.
2. Degradation of the amino acid molecules into simpler components.
3. Alteration of side chains while maintaining the  $\alpha$ -amino-carboxylic acid grouping which is the ninhydrin positive group.

4. Decarboxylation.
5. Transamination or transferring the amino group to another molecule.
6. Oxidative deamination to  $\alpha$ -keto acids.
7. Deamidation of the amide molecules to produce the respective amino acid.

Conditions of temperature, pH, enzyme activity, bacterial action, et cetera govern which reaction(s), if any, will occur. Therefore, a change in amounts of an amino acid probably indicates some chemical change has taken place, but without knowing all of the existing conditions, it is usually impossible to predict reliably the metabolic pathway which a particular amino acid has followed.

In both cultivars, some amino acids remained almost quantitatively the same throughout the storage time at both temperatures (Tables 1 and 2). For example, threonine, glycine, tryptophan, methionine, phenylalanine, and  $\alpha$ -amino-n-butyric acid did not appear to change significantly in either cultivar. The combination of serine, glutamine, and asparagine decreased in both cultivars during early storage at the 36°F storage temperature. At 51°F it decreased somewhat in cultivar D from the beginning, but in cultivar A, at 51°F, the combination increased up to the first month then decreased. In cultivar A, Gaba decreased gradually and at almost identically the same rate at both temperatures, but in cultivar D, there was a decrease at both storage temperatures the first 2 weeks, and at 51°F again during the fourth month. Glutamic acid showed some increase in both cultivars after the first 2 weeks, with the greatest increase during the fourth month, at which time cultivar D showed a greater increase than cultivar A. This increase was probably due to some glutamine deamidation to glutamic acid. Aspartic acid showed a decrease in early storage for both cultivars at both temperatures, then cultivar A, at 51°F, showed a rather sharp increase from 2 weeks to the first month. Cultivar D had its greatest increase in aspartic acid, at 51°F, during the fourth month. Proline showed a highly significant increase in cultivar D, at 51°F, after the second month, while at 36°F it stayed almost stable, as it did at both storage temperatures in cultivar A. Leucine, isoleucine, valine, and phenylalanine showed almost identical patterns of change with one another and between cultivars. Each showed an increase, at 51°F, and some decrease, at 36°F, early in storage, and practically no additional change after the first month. Lysine and histidine increased in both cultivars from the second through the fourth month at 51°F.

Table 1. Cultivar A pressed juice amino acids, amides, and ammonia in control and root storage samples, stored at two temperatures for five different storage periods.

Amino Acids	Control	2 Weeks		1 Month		2 Months		3 Months		4 Months		
		36°F	51°F	36°F	51°F	36°F	51°F	36°F	51°F	36°F	51°F	
1. ASP <sup>1/</sup>	211.4	2/	197.8	182.6	213.4	236.0	231.9	222.8	213.1	212.6	192.5	209.4
2. THR <sup>3/</sup>	30.6	25.6	28.9	29.2	34.4	30.5	33.0	25.4	33.5	20.3	38.9	
3. SER <sup>4/</sup>	447.4	443.4	488.4	391.8	515.1	395.6	502.6	348.7	482.5	319.1	436.3	
4. HOMOSER	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5. GLU	53.5	36.9	29.4	36.5	48.7	33.2	48.4	36.6	56.7	40.8	82.4	
6. PRO	24.6	25.3	29.2	24.6	38.5	24.5	34.7	26.7	33.8	21.4	35.3	
7. CIT	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
8. GLY	4.6	4.7	5.0	3.9	5.2	3.6	4.0	3.4	5.4	3.4	6.8	
9. ALA	26.3	24.2	27.8	21.1	30.1	21.3	26.2	17.8	25.6	19.5	34.6	
10. VAL	31.4	35.5	39.1	29.4	44.6	31.0	40.6	25.3	39.3	22.5	40.4	
11. PIP	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
12. MET	3.8	3.9	4.8	3.1	4.0	2.7	4.7	3.1	5.3	3.2	8.0	
13. ILE	52.5	53.6	61.5	47.3	67.7	47.6	60.0	39.7	57.4	33.4	53.4	
14. LEU	56.5	59.5	69.6	53.5	77.1	48.4	69.8	37.5	65.2	34.2	61.7	
15. DOPA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
16. TYR	0.0	T	T	T	T	1.7	3.2	1.8	2.4	1.6	2.5	
17. PHE	11.3	8.2	14.8	5.7	13.9	5.7	11.3	5.1	11.8	5.2	12.5	
18. NH <sup>3/</sup>	24.6	28.0	23.3	23.0	25.9	21.3	23.1	20.5	28.7	17.5	28.0	
19. GABA	190.7	192.4	195.4	185.3	184.5	168.2	176.5	153.5	164.5	143.3	140.5	
20. ORN	T	T	T	T	T	T	T	T	T	0.6	1.0	
21. LYS	16.8	15.6	17.7	14.6	17.8	13.2	17.8	12.9	20.4	14.6	25.9	
22. HIS	7.4	10.2	11.3	10.5	14.9	12.6	15.3	11.8	18.4	12.8	18.5	
23. TRY	7.0	7.8	7.8	8.3	9.0	8.0	8.9	6.3	8.6	6.8	8.2	
24. ARG	35.1	52.2	49.5	49.3	66.5	57.8	74.9	60.3	84.3	65.9	85.6	
25. $\alpha$ -NH <sub>2</sub> -N-BUT	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.0	0.6	0.0	0.6	

1/ 1. aspartic 2. threonine 3. serine 4. homoserine 5. glutamic 6. proline 7. citrulline 8. glycine  
 9. alanine 10. valine 11. pipeolic 12. methionine 13. isoleucine 14. leucine 15. 3,4-dihydroxy-  
 phenylalanine 16. tyrosine 17. phenylalanine 18. ammonia 19. gamma-aminobutyric acid 20. ornithine  
 21. lysine 22. histidine 23. tryptophan 24. arginine 25.  $\alpha$ -amino-n-butyric acid.  
 2/ mg per 100 ml pressed juice, RDS 100.  
 3/ combination of serine, glutamine, and asparagine.  
 4/ trace amounts.

Table 2. Cultivar D pressed juice amino acids, amides, and ammonia in control and root storage samples, stored at two temperatures for five different storage periods.

Amino Acids	Control	2 Weeks		1 Month		2 Months		3 Months		4 Months	
		36°F	51°F	36°F	51°F	36°F	51°F	36°F	51°F	36°F	51°F
1. ASP <sup>1/</sup>	276.9	249.9	218.3	237.6	217.1	221.9	226.5	230.8	220.6	266.2	216.3
2. THR <sup>2/</sup>	40.0	33.8	38.7	34.2	43.4	32.1	47.8	34.9	50.8	37.9	52.4
3. SER <sup>3/</sup>	532.7	466.6	520.9	400.3	494.1	380.3	463.5	378.2	445.9	358.2	417.5
4. HOMOSER	T <sup>4/</sup>	T	T	T	T	0.0	0.0	0.0	0.0	0.0	0.0
5. GLU	44.3	25.9	24.0	27.0	40.0	22.0	50.1	30.5	63.0	37.7	109.5
6. PRO	29.0	28.2	31.0	27.7	38.6	30.6	41.1	30.8	77.1	33.6	102.1
7. CIT	T	T	0.0	0.0	0.0	0.0	0.0	0.0	T	T	0.2
8. GLY	8.2	6.0	6.2	5.4	6.8	5.2	7.3	4.9	8.7	5.6	12.1
9. ALA	44.2	30.6	35.2	25.8	43.5	21.4	44.0	22.1	44.2	28.3	52.2
10. VAL	47.4	43.2	46.4	38.1	50.3	38.0	51.4	39.1	52.1	41.5	51.6
11. PIP	T	T	T	T	T	occ. <sup>5/</sup>	occ.	occ.	occ.	occ.	occ.
12. MET	6.3	6.0	5.4	3.6	4.5	3.0	5.4	3.4	6.4	4.1	9.2
13. ILE	72.4	64.2	69.9	60.0	71.7	55.9	70.1	56.5	70.0	57.4	64.2
14. LEU	80.7	76.7	81.2	63.8	82.0	65.0	79.6	63.4	82.1	68.4	75.9
15. DOPA	T	T	T	T	T	T	1.8	1.7	2.5	2.0	3.4
16. TYR	0.6	T	T	1.3	3.3	1.5	5.2	1.8	4.1	4.7	19.5
17. PHE	15.2	11.1	17.3	9.1	18.1	7.5	17.6	6.5	19.6	14.9	22.8
18. NH <sub>3</sub> <sup>2/</sup>	23.8	22.0	22.8	19.3	22.2	21.3	24.0	18.9	26.2	20.0	29.2
19. GABA	253.5	223.0	204.0	185.7	194.2	169.7	191.6	176.0	198.8	197.0	162.6
20. ORN	0.2	T	T	T	T	T	0.4	0.4	0.7	0.4	1.6
21. LYS	23.8	21.3	21.8	17.5	18.8	15.4	18.7	16.8	24.1	18.6	34.2
22. HIS	11.4	13.9	13.4	11.8	15.6	14.1	18.8	17.3	23.1	18.2	25.3
23. TRY	11.4	10.0	9.6	10.3	10.2	9.6	11.1	9.6	11.4	11.3	12.7
24. ARG	56.7	67.8	66.7	74.1	74.3	85.3	85.6	88.7	115.1	111.1	119.6
25. $\alpha$ -NH <sub>2</sub> -n-BUT	13.6	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7

<sup>1/</sup> See Table 1.

<sup>2/</sup> mg per 100 ml pressed juice, RDS 100.

<sup>3/</sup> Combination of serine, glutamine and asparagine.

<sup>4/</sup> Trace amounts.

<sup>5/</sup> Occluded peaks.

Some of the changes mentioned in the individual amino acids are probably not significant statistically, but they emphasize the difference in response among the amino acids to the storage conditions.

Perhaps this study would have shown greater significant differences in some of the N components, especially the amino acids, if we could have studied the changes in the sugarbeet samples from harvest time through the controlled storage periods. Some changes, due to enzymatic action, probably had occurred during the 15 day period before the control sugarbeets were sampled. It would be interesting to continue this study on that basis at a later date.

#### EFFECT OF ETHREL AND OTHER CHEMICALS ON THE INDUCTION OF POLLEN STERILITY IN SUGARBEET

R. J. Hecker and G. A. Smith

A recent paper by Rowell and Miller (1) reported the induction of usable male sterility in wheat by the application of Ethrel (2-chloroethylphosphonic acid). One foliar application of Ethrel at 1000 to 2000 ppm appears to induce virtual pollen sterility with limited phytotoxic and morphological effects. This induced male sterility may allow circumvention of the serious pollination and fertility restoration problems which have been delaying the development of commercial hybrid wheat.

In 1967 we commenced experiments comparing the gametocidal effect of Ethrel, FW-450 (sodium 2,3-dichloroisobutyrate), oestrone (female sex hormone), and arsenic acid. We have reported on these various experiments in the Sugarbeet Research Reports of 1968, 1969, and 1970. This 1971 report will summarize our work.

We applied these chemicals as foliar sprays and also directly into the vascular system, in a wide range of concentrations, and at various intervals of time and growth. Oestrone had a generally small effect on induction of pollen sterility. Also this effect appeared to depend on the genotype of the plant. Oestrone is only slightly soluble in water (30 ppm), hence, the concentration in the plants was

low. Oestrone in water was not phytotoxic but other solvents in which oestrone was more soluble proved to be much too phytotoxic on sugarbeet. Oestrone did not appear to have any practical value as a gametocide.

Arsenic acid could not be applied above 200 ppm because of toxicity. It appeared to have no gametocidal effect.

Ethrel could not be applied above 300 ppm because of its gross morphological (witch's broom) effect and because flowers failed to develop. At 200 ppm Ethrel caused some reduction of pollen viability in certain genotypes, particularly when applied frequently (up to 10 applications). Sugarbeet will not tolerate treatment with 1000 to 2000 ppm of Ethrel which is the concentration necessary to emasculate wheat.

FW-450 was more effective and consistent in its gametocidal effect than Ethrel. However, we and others have had sufficient experience with FW-450 so that we feel it has very limited use because of its incomplete effectiveness and phytotoxicity. Our experiments indicate that Ethrel, though useful on wheat, has little or no practical value as a gametocide on sugarbeet.

#### Literature Cited

- (1) Rowell, P. L. and D. G. Miller. 1971. Induction of male sterility in wheat with 2-chloroethylphosphonic acid (Ethrel). *Crop Science* 11: 629-631.

#### RHIZOCTONIA RESISTANCE FIELD RESEARCH, 1971

R. J. Hecker and E. G. Ruppel

Field studies of Rhizoctonia root and crown rot (*R. solani*) of sugarbeet were conducted in a 1.5 acre, sprinkler-irrigated field on our BSDF-leased farm near the CSU Agronomy Research Center at Fort Collins. The breeding program for Rhizoctonia resistance was under the direction of Mr. J. O. Gaskill until his retirement May 31, 1971. The following experiments, in addition to several selection blocks, were included in the Rhizoctonia field:

R-1: Interaction of sugarbeet strains x Rhizoctonia isolates

- R-2: Rhizoctonia inoculation methods
- R-3: Estimation of environmental variance of Rhizoctonia infection
- R-4: Rhizoctonia resistance evaluation of contributed lines
- R-5: Rhizoctonia evaluation of regional cooperative test of LSR-CTR varieties
- R-6: Comparison of lines with different amounts of selection for Rhizoctonia resistance
- R-7: Rhizoctonia resistance of individual plant progenies
- R-8: Rhizoctonia resistance evaluation of top-cross hybrids and parents
- R-9: Preliminary study on the biochemical nature of Rhizoctonia resistance

Except for Experiment R-2, the rosette method was used to inoculate all plants. Dry, ground barley-grain inoculum of isolate R-9 (=B-6) was used for all inoculations, except in Experiment R-1 in which five isolates were compared. One-row plots 20 feet long and 22 inches apart were planted May 18. Inoculations, with the exception of Experiment R-2, were made July 27 and 28. Roots were dug September 27 to October 6 and individually rated for severity of root rot. The disease index (D.I.) ratings were based on a scale of 0 to 7; 0 = healthy, 7 = dead. Means for percent healthy roots (ratings 0 and 1) and percent harvestable roots (ratings 0 through 3) were calculated. We considered classes 1 through 3 to be processable roots, although they might not be storable. We consider the disease index to be the best measure of genetic resistance. Disease severity was satisfactory for comparisons of inherent resistance among lines; however, the epidemic was probably a little too mild for good differentiation in the selection blocks. Earlier inoculation of selection blocks will be practiced in the future.

Experiments R-1, R-2, R-3, and R-4 are described separately in this report; Experiment R-5 is included in the Regional Cooperative LSR-CTR test. Experiments R-6, 7, 8, and 9 are described below.

Experiment R-6: Comparison of Lines with Different Amounts of Selection for Rhizoctonia Resistance.

We compared the resistance of 15 lines from the Rhizoctonia resistance breeding program to evaluate the progress made by continued selection in the original resistant lines, and the relative effect

of selection after introducing new germplasm. The test was a randomized complete block with 10 replications. Results of this test are summarized in Table 1.

Rhizoctonia resistance has continued to improve with selection in the FC 701 and FC 702 series. Selection lines FC 701/5 and FC 702/5 showed the greatest resistance with respective indices of 1.17 and 1.20, as compared to 3.72 and 3.42 for their original source populations. This represents a significant improvement in resistance to Rhizoctonia root and crown rot; however, we have not achieved immunity as evidenced by the fact that these two lines had only 61.9 and 63.0% healthy roots. Further improvement is being attempted.

FC 703 (entry 884) has a respectable disease index (1.49), which is significantly lower than FC 701 and FC 702. FC 703 is the  $F_2$  of FC 702 x FC 701. One cycle of selection for Rhizoctonia resistance was made in the  $F_1$  generation. FC 703 should be a good source from which to make further selection, since there has been opportunity for recombination of genes from both parents.

Selection progress appears to be a function of selection pressure (intensity of infection). This would explain the trend toward superiority of the /5 lines (6 cycles of selection) over the /4 lines (also 6 cycles of selection); the roots from which the /5 seed was produced had been selected under severe Rhizoctonia infection, whereas those producing the /4 seed had been selected under a mild infection.

Continued progress toward resistance by the use of mass selection indicates that there is still considerable genetic variability for resistance in the selected lines. Since mass selection has been effective it is likely that the action of many of the resistance genes is additive. Some confirmation of additive gene action may be possible in an inheritance study planned for 1972.

Entry 883 (D.I. 2.91) has had only one cycle of mass selection since the cross with LSR-CTR germplasm, whereas entries 885 and 886 (D.I. 2.30 and 1.84) have had two cycles of selection. These comparisons indicate that lines resulting from LSR-CTR x Rhizoctonia resistant crosses have responded to selection for Rhizoctonia resistance and, hopefully, should ultimately lead to the combination of resistance to all three diseases. A separate study is in progress which should give us information about the effectiveness of back-crossing to incorporate Rhizoctonia resistance.

It remains to be determined if any of our current Rhizoctonia resistant lines can be used directly as pollinators for production

Table 1. Population means for disease index, % healthy roots (roots with ratings of 0 and 1), and % harvestable roots (roots with ratings of 0 through 3), and multiple range comparisons (means followed by the same letter are not significantly different at the 5% point); Experiment R-6, 1971, Fort Collins, Colorado.

Entry no.	Seed no.	Description	Disease index	Healthy %	Harvestable %
873	681008-0	FC 701; from GW 674-56C; 4 cycles Rhiz. res. sel.	2.02 cd	45.3 cd	68.2 de
874	671007-0	FC 702/2; from GW 674-56C; 5 cycles Rhiz. res. sel.	1.45 efg	57.5 a	77.1 abc
875	691246-00	FC 701/4; from GW 674-56C; 6 cycles Rhiz. res. sel.	1.38 fg	56.8 ab	78.7 abc
876	701000-0	FC 701/5; from GW 674-56C; 6 cycles Rhiz. res. sel.	1.17 g	61.9 a	86.2 a
877	Acc. 2168	GW 674-56C; LSR comm. OP var.; MM	3.72 a	21.3 f	38.8 g
878	681009-0	FC 702; from C 817; 4 cycles Rhiz. res. sel.	2.11 cd	43.1 cd	65.7 e
879	671008-0	FC 702/2; from C 817; 5 cycles Rhiz. res. sel.	1.83 de	47.3 c	70.6 cde
880	691247-00	FC 702/4; from C 817; 6 cycles Rhiz. res. sel.	1.75 def	49.5 bc	67.8 de
881	701001-0	FC 702/5; from C 817; 6 cycles Rhiz. res. sel.	1.20 g	63.0 ■	79.5 ab
882	621220HO	C 817; High comb. syn. from GW 359-52R	3.42 a	24.0 f	42.0 g
883	701223H001	Interpol. $F_3$ families fr. LSR-CTR x Rh.res; 2 cyc sel.	2.91 b	32.1 e	52.3 f
884	691001-0	FC 703; FC 702 x FC 701, $F_2$	1.49 efg	57.2 ab	72.7 bcde
885	691248-(03)	FC 801; $F_4$ plant fr. LSR-CTR x Rh.res.; 4 cyc sel.	2.30 c	39.0 de	64.8 e
886	691248-(02)	$F_4$ plant fr. LSR-CTR x Rh.res.; 4 cycles sel.	1.84 de	48.7 bc	68.4 de
887	691901-00	Pool of sels. from C 817; 5 cycles sel.	1.47 efg	56.4 ab	75.1 bcd

of hybrids. We have limited top-cross data this year in Experiment R-8, and some of the commercial breeders should have more extensive data this year. In our 1970 Report we showed that there is considerable variability for root yield and sucrose in FC 701/2, which indicates that there is potential for combining ability improvement, if necessary.

The percent of healthy and harvestable roots rank the lines in essentially the same order as did the disease index. These percentage values may be useful as practical measures of the resistance of various breeding lines.

Experiment R-7: Rhizoctonia Resistance of Individual Plant Progenies.

Eighteen progeny lines were evaluated for Rhizoctonia resistance. These lines were from a long-term experiment to improve Rhizoctonia resistance by the mother-line breeding method, and to evaluate the breeding method. Five of the progeny lines had a smaller disease index than the resistant check (FC 701/4), although the differences were not significant. The most superior progeny lines will be recombined to form the population for the next selection cycle.

Experiment R-8: Rhizoctonia Resistance Evaluation of Top-Cross Hybrids and Parents.

This was a test similar to R-4 (company contributed hybrids and parents), except that all the CMS females in this test were LSR and LSR-CTR lines developed at Fort Collins. There were 13 hybrids in the test. Only two of the 13 hybrids failed to show some degree of dominance for Rhizoctonia resistance (where the disease index of the hybrid was greater than the mid-parent). In one case the female parent was somewhat resistant (D.I. = 2.67), but in the other case the female was quite susceptible (D.I. = 4.20). In experiment R-4 there were four hybrids out of 13 in which resistance showed no dominance. In all four cases the female parents tended toward being resistant ( $D.I. \leq 2.7$ ). From these data, and the limited data of previous years, it appears that the Rhizoctonia resistance in the FC 701 and FC 702 lines and sub-lines exhibits partial dominance in most crosses, particularly in those crosses of resistant with highly susceptible genotypes. This demonstration of partial dominance is encouraging since it may develop that Rhizoctonia resistance in only one parent of a final hybrid cross may provide adequate resistance in a commercial hybrid variety.

Experiment R-9: Preliminary Study on the Biochemical Nature of Rhizoctonia Resistance.

This experiment provided plant materials for preliminary studies of biochemical differences between healthy and infected plants of

Rhizoctonia susceptible and resistant genotypes. Two Rhizoctonia resistant lines (FC 701/2 and FC 702/2) and two susceptible lines (GW 674-56C and C 817) were included. Ten feet of each 20-foot plot was inoculated. Tissue from healthy and infected plants was collected September 15, treated with sulfosalicylic acid to stop enzymatic action, and stored frozen for later analyses. Tests will be conducted in an attempt to detect biochemical differences which may have resulted from infection, or which may be related to the inherent resistance level of the plant. Mrs. Maag is cooperating in this experiment.

#### RHIZOCTONIA RESISTANCE EVALUATIONS OF CONTRIBUTED SUGARBEET LINES, EXPERIMENT R-4, 1971

E. G. Ruppel, R. J. Hecker, and J. O. Gaskill

A randomized complete block design with six replications was used to evaluate 38 sugarbeet hybrids, breeding lines, and cultivars for resistance to Rhizoctonia root rot in the field at Fort Collins, Colorado, in 1971. Entries consisted of 13 hybrids, their male sterile female parents and resistant pollinators, and several susceptible and resistant controls. One-row plots were 20 feet long and 22 inches apart. Planting was done on May 18. Hand thinning to a spacing of 10 to 12 inches in the row was performed about 4 weeks later. The rosette method was used to inoculate the plants on July 27 with R. solani isolate R-9 (=B-6). This isolate has been used for several years for initiating epidemics of root rot in our breeding nurseries.

At harvest (September 27 to October 6), all plants were dug by hand and rated individually for root rot severity. The ratings were based on a scale of 0 to 7, with 0 = healthy and 7 = dead. A disease index was calculated as follows:

$$D.I. = \frac{\left( \begin{array}{l} \text{Sum} \\ \text{of} \\ \text{disease} \\ \text{class} \end{array} \times \begin{array}{l} \text{number of plants} \\ \text{in that class} \end{array} \right)}{\text{Total number of plants}}$$

Sugarbeets in classes 0 to 1 were combined to calculate percentage healthy roots. Disease class 1 consisted of roots with small, inactive lesions in the crowns. Hence, these roots were considered to be essentially healthy. Percentage harvestable roots included classes 0, 1, 2, and 3. Beets in these classes were deemed harvestable and could be processed without difficulty. In the analyses of

Table 1. Rhizoctonia resistance evaluation of contributed lines, Experiment R-4, Fort Collins, Colorado, 1971.

Entry <sup>1/</sup>	Number and/or description	Disease <sup>2/</sup> index	% Healthy	% Har- <sup>4/</sup> vestable
821-A	$F_1$ , ACS 21 HO (cms) x FC 702/2	2.6 ghijkl	35.1 efghijk	57.3
822-A	ACS 21 HO (cms)	4.8 b	13.5 mn	29.1
823-A	$F_1$ , (ACS 21 HO x ACS 6) cms x FC 702	2.4 ghijkl	41.1 defghi	70.1
824-A	(ACS 21 HO x ACS 6) cms	3.3 cdefg	27.2 hijklm	49.5
825-A	$F_1$ , ACS 68-313ms x FC 702/2	2.4 ghijkl	46.3 cdefgh	67.9
826-A	ACS 68-313ms	4.0 abc	17.2 jklmn	34.8
827-B	I-209 B <sub>3</sub> ms x FC 701	2.8 efghij	33.6 fghijkl	56.5
828-B	I-209 B <sub>3</sub> ms	4.3 ab	17.3 jklmn	35.7
829-B	AI-83ms <sup>3</sup> x FC 701	2.6 ghijkl	40.7 efghi	62.1
830-B	AI-83ms	2.7 ghijkl	37.2 efghij	65.7
831-B	AI-81ms x FC 701	2.3 hijkl	46.2 cdefgh	70.2
832-B	AI-81ms (SP 68519-01)	4.0 abc	18.5 jklmn	43.1
833-B	AI-82ms x FC 701	1.9 jklm	52.1 cdefg	84.1
834-B	AI-106ms (equiv. to AI-82ms)	1.7 klm	61.1 abcd	83.5
835-B	AI-84ms x FC 701	2.1 ijklm	49.6 cdefgh	77.1
836-B	AI-84ms	2.0 ijklm	55.1 bcdef	85.7
837-B	AI-62ms x FC 701	2.2 hijklm	48.7 cdefgh	72.4
838-B	AI-62ms	3.7 bcde	20.0 jklmn	42.6
839-B	I-249 B <sub>3</sub> ms x FC 701	3.0 defgh	30.6 ghijklm	50.4
840-B	I-249 B <sub>3</sub> ms - 68L	4.9 a	9.7 n	20.1
841-B	I-214 B <sub>3</sub> ms x FC 701	2.7 efghij	32.3 fghijklm	60.8
842-B	I-214 B <sub>3</sub> ms	4.0 abc	17.6 jklmn	30.7
843-B	I-224 B <sub>1</sub> ms x FC 701	2.5 ghijkl	37.4 efghij	62.0
844-B	I-224 B <sub>1</sub> ms	2.7 fghijk	41.5 cdefghi	55.0
845-B	I-316 B <sub>1</sub> ms x FC 701	2.9 defghi	28.4 hijklm	60.6
846-B	I-316 B <sub>2</sub> ms	4.5 ab	6.1 n	20.2
847-C	H 71105	3.8 bcd	15.9 klmn	40.3
848-C	H 7001	4.1 abc	14.6 lmn	35.2
849-C	H 69117	3.6 bcdef	17.6 jklmn	47.8
850-D	FC 701 (4 cyc. sel. GW 674-56C)	2.0 ijklm	57.7 abcde	79.2
851-D	FC 701/2 (5 cyc. sel.)	1.7 lm	64.2 abc	83.7
852-D	FC 701/5 (6 cyc. sel.)	1.3 m	76.3 a	92.3
853-D	FC 702 (4 cyc. sel. C 817)	2.0 ijklm	54.0 bcdef	79.2
854-D	FC 702/2 (5 cyc. sel.)	2.0 ijklm	53.3 bcdefg	81.9
855-D	FC 702/5 (6 cyc. sel.)	1.3 m	73.9 ab	94.5
856-D	GW 674-56C (FL #608)	3.3 cdefg	25.8 ijklm	47.2
857-D	C 817 (from GW 359-52R)	2.9 defghi	29.8 hijklm	54.3
858-D	US H20; SL(129 x 133) x SP 6322-0	3.3 cdefg	19.6 jklmn	50.8

- 1/ Fort Collins entry number followed by contributor designation. A = American Crystal Sugar Company, B = Great Western Sugar Company, C = Spreckels Sugar Company, D = U.S. Department of Agriculture, Fort Collins, Colorado.
- 2/ Disease index based on scale of 0 to 7, with 0 = healthy and 7 = dead. Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.
- 3/ Classes 0 and 1 combined to calculate percentage healthy roots. Bliss' arcsine transformation was used for the analysis of variance and Duncan's multiple range test. Means followed by the same letter are not significantly different at the 5% level.
- 4/ Classes 0 through 3 were combined to calculate percentage harvestable beets.

percentage healthy roots, Bliss' arcsine transformation (to degrees) was used.

Results of the overall test (Table 1) show a general trend toward the superiority of lines FC 701 and FC 702 and their derivatives over their source cultivars, GW 674-56C and C 817, respectively. Most hybrids between a susceptible female parent and a resistant pollinator show a trend toward dominance for resistance. The four cases of no dominance in hybrids occurred when the female parent had a disease index of 2.7 or less. In no case was resistance of a hybrid significantly better than that of its resistant parent. Differences among the FC resistant lines were not significant.

#### STUDY OF ENVIRONMENTAL VARIANCES ASSOCIATED WITH RHIZOCTONIA RESISTANCE

R. J. Hecker and E. G. Ruppel

To conduct certain basic genetic studies of Rhizoctonia resistance in sugarbeet, it is necessary that the environmental variance be estimated. Two ways in which environmental variances are ordinarily estimated are: 1) direct estimation by the variance of non-segregating populations, and 2) by a components of variance analysis of particular related populations.

An experiment (R-3, 1971) was designed to test the feasibility of estimating the environmental variance in genetic and heritability

studies of *Rhizoctonia* resistance by the direct method of using non-segregating populations. We have found this method satisfactory to estimate environmental variances associated with sucrose content, various quality characters, and even root yield after a scale change or regression estimation.

Table 1 lists the nine populations in this experiment: four were nonsegregating and five were segregating. The four homogeneous populations included two highly inbred lines (entries 813 and 814), and two  $F_1$  hybrids (entries 811 and 812). The  $F_1$ 's were developed from unrelated inbred lines. The disease indices of these four populations show that they range from susceptible to highly susceptible in regard to *Rhizoctonia*. Total within-plot variances were calculated on original individual plant indices. These variances included no variability due to replications. The two inbreds (entries 813 and 814) had very large variances, whereas the  $F_1$ 's (entries 811 and 812) had variances ranked between the susceptible and resistant heterogeneous populations (entries 815 to 819). Obviously, the variances of homogeneous populations do not directly estimate the environmental variance associated with *Rhizoctonia* infection. It is not surprising that the resistant entries had smaller variances than their susceptible sources, since the former have had five cycles of selection for resistance. Despite this selection, evidence from our breeding program indicates that in these resistant lines there is still some heterogeneity at those loci conditioning resistance. Thus, we expected the resistant entries (815, 816, and 817) to have more genetic variance than the homogeneous entries, since the latter should be homogeneous at virtually all loci. Our data, however, indicate that our nonsegregating populations, particularly our inbreds, varied widely in intensity of infection from one environment or microenvironment to another.

Table 1. Disease index means and total within-plot variances for nine populations in Experiment R-3, 1971. Means followed by the same letter are not significantly different at the 5% level.

Entry no.	Population	Description	Disease index	Total within plot variance	
				Original scale	Log scale
811	52-305 CMS x 52-430, $F_1$	Homogeneous $F_1$ hybrid	4.09 b	1.82	.022
812	34 CMS x 52-407, $F_1$	Homogeneous $F_1$ hybrid	2.31 de	2.21	.050
813	52-307	Inbred	3.36 bc	5.50	.081
814	816	Inbred	5.41 a	4.56	.050
815	FC 701/2	Rhizoc. resistant	1.26 f	1.13	.040
816	FC 702/2	Rhizoc. resistant	1.44 ef	1.52	.052
817	FC 703	Rhizoc. resistant	1.29 f	1.48	.050
818	C 817	Source of FC 702; Rhizoc. susc.	2.95 cd	2.38	.055
819	GW 674-56C	Source of FC 702; Rhizoc. susc.	2.71 cd	3.10	.063

Since variances of the homogeneous populations cannot be used as direct measures of environmental variance, and since there was a significant relationship between the means and variances, a log transformation was performed. The variances of the log data in Table I are considerably different than the variances of the original data. However, three of the homogeneous entries (812, 813, and 814) still had total within-plot variances that were equal to or greater than the variances of the heterogeneous entries. Other transformations are not likely to be more satisfactory. It appears from this experiment that one cannot use direct or log variances as estimates of environmental variance for *Rhizoctonia* infection. Without a measure of environmental variance, estimating relative genetic variances, heritabilities, and types of gene action conditioning *Rhizoctonia* resistance will be more complicated. Consequently, selecting the most efficient methods of breeding for *Rhizoctonia* resistance will be more difficult.

#### PRELIMINARY STUDY ON GROWTH OF RHIZOCTONIA ON LEAF-EXTRACT MEDIA PREPARED FROM RESISTANT AND SUSCEPTIBLE SUGARBEETS

E. G. Ruppel

Growth of *Rhizoctonia solani* (isolate R-9) was measured on leaf-extract-agar media prepared from 3-month-old inoculated and noninoculated plants of susceptible cultivar GW 674-56C and resistant cultivar FC 701/2, a selection from GW 674-56C. Media were prepared as described by Calpouzos and Stallknecht (1) 15 days after inoculation of the roots. Linear growth of the fungus was measured at 24, 48, 72, and 96 hours after planting. A randomized block design was used with 10 replications.

Results in Table 1 indicate that after 48, 72, and 96 hours, there were no significant differences in growth on media prepared from inoculated or noninoculated plants of GW 674-56C, or noninoculated plants of FC 701/2. However, growth on these media was significantly greater than growth on the medium from inoculated FC 701/2 plants. The nonsignificant differences in growth among media at 24 hours is attributed to slight differences in the nutrient effect of the mycelium-agar inoculum piece used to "seed" the test plates.

These results tentatively suggest that some heat-stable substance(s) is present in leaf extracts of inoculated plants of FC 701/2 that inhibits the growth of *R. solani* in culture. The nonsignificant differences in growth among the other media indicate that the response is not simply due to differences in percentage sucrose between the resistant and susceptible cultivars. Further studies are needed on the nature of resistance in sugarbeet to *Rhizoctonia* before definite conclusions can be drawn.

#### Literature Cited

- (1) Calpouzos, L. and G. F. Stallknecht. 1966. Phototropism by conidiophores of *Cercospora beticola*. *Phytopathology* 56: 702-704.

Table 1. Linear growth of Rhizoctonia solani at 24, 48, 72, and 96 hours on leaf-extract-agar media prepared from inoculated and noninoculated plants of susceptible cultivar GW 674-56C and resistant cultivar FC 701/2.

Cultivar (Medium source)	Treatment <sup>1/</sup>	Growth in mm at <sup>2/</sup>			
		24 hr	48 hr	72 hr	96 hr
GW 674-56C	I	22.1 c	40.3 a	59.0 a	78.1 a
	N	23.3 b	41.4 a	59.7 a	79.3 a
FC 701/2	I	19.1 d	33.8 b	49.2 b	65.4 b
	N	23.5 a	41.6 a	59.9 a	78.2 a

1/ I = inoculated; N = noninoculated. Plants 3 months old at inoculation of roots; media prepared from leaves 15 days after inoculation.

2/ Means of 10 replications; means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

#### REACTION OF ROOT-ROT RESISTANT AND SUSCEPTIBLE SUGARBEET CULTIVARS TO FOLIAR-BLIGHT ISOLATES OF RHIZOCTONIA SOLANI

E. G. Ruppel

Root rot.--Two-month-old plants of susceptible cultivar GW 674-56C and resistant cultivar FC 701/2 were inoculated with mycelium from 3-day-old cultures of Rhizoctonia solani (foliar isolates R-6, R-7, and root isolate R-9). Half the plants were inoculated by placing a 5-mm<sup>2</sup> piece of inoculum against the tap root about 2 cm below the soil surface. The remaining roots were inoculated by inserting the inoculum piece in a wound made in the tap root with a sterile scalpel about 2 cm below the soil surface. The wounds were covered with lanolin to prevent desiccation. A randomized block design was used with three replications. Roots were harvested 35 days after inoculation and rated 0 to 5, with 0 = healthy and 5 = 100% rot.

Results in Table 1 show that the foliar-blight isolates were capable of infecting wounded beet roots; however, the degree of rotting was significantly less than that caused by the root isolate regardless of cultivar. The cultivar X isolate interaction was nonsignificant, indicating that the isolates' relative behavior was similar in both cultivars.

Foliar blight.--Mycelial suspensions of foliar isolates R-6 and R-7 were atomized on 2-month-old plants of susceptible cultivars GW 674-56C and C 817, and resistant cultivars FC 701/2 and FC 702/2. The plants were held in a humidity chamber for 6 days under constant light (ca. 520 ft-c) at 100% relative humidity and 30 to 32 C. Ratings for foliar-blight severity were based on a scale of 0 to 5, with 0 = healthy and 5 = complete defoliation. A randomized block design was used with five replications.

Results in Table 2 show that both isolates incited appreciable blight in all cultivars. Differences between isolates were not significant. Disease severity in cultivars FC 701/2 and FC 702/2 was not significantly different from each other regardless of isolate. The difference between C 817 and GW 674-56C also was not significant. Disease severity in both root rot resistant lines (FC 701/2 and FC 702/2) was significantly greater than that of GW 674-56C and C 817. The cultivar X isolate interaction was nonsignificant, indicating that relative isolate behavior was similar in all lines.

#### Discussion

Some foliar isolates apparently can incite rot of sugarbeet roots when introduced through wounds. However, even with wounds, spread of these isolates within the tissue was minimal as was the amount of rotting induced.

In a previous report (Sugarbeet Research, 1970 Report, p. D27-D29), analysis of root-rot pathogenicity tests with nine isolates of R. solani and two sugarbeet cultivars indicated that the isolates X lines interaction was significant when both foliar and root isolates were included. This interaction, and the increased disease severity of FC 701/2 and FC 702/2 in the foliar test reported herein, may indicate that resistance of these lines to *Rhizoctonia* root rot may not be expressed against foliar blight.

Table 1. Reaction of root-rot resistant (FC 701/2) and susceptible (GW 674-56C) sugarbeet cultivars to root inoculation with two foliar (R-6, R-7) and one root (R-9) isolate of Rhizoctonia solani by two methods of inoculation.

Line	Isolate	Inoculation method	Disease rating <sup>1/</sup>
FC 701/2	R-6	Wound	0.5
		Nonwounded	0.0
	R-7	Wound	1.0
		Nonwounded	0.0
	R-9	Wound	4.0
		Nonwounded	3.3
GW 674-56C	R-6	Wound	0.5
		Nonwounded	0.0
	R-7	Wound	1.0
		Nonwounded	0.0
	R-9	Wound	3.3
		Nonwounded	5.0

<sup>1/</sup> Based on a scale of 0 to 5, with 0 = healthy and 5 = 100% rot. Means of three replications.

Table 2. Reaction of root-rot resistant (FC 701/2 and FC 702/2) and susceptible (GW 674-56C and C 817) sugarbeet cultivars to foliar inoculation with two foliar-blight isolates of Rhizoctonia solani.

Line (L)	Isolate (I)	Disease rating <sup>1/</sup> (L) X (I)	Disease rating <sup>2/</sup> (L)
FC 701/2	R-6	3.4	
	R-7	3.0	3.2 a
FC 702/2	R-6	3.4	
	R-7	3.6	3.5 a
GW 674-56C	R-6	2.4	
	R-7	2.6	2.5 b
C 817	R-6	1.6	
	R-7	2.4	2.0 b

<sup>1/</sup> Based on scale of 0 to 5, with 0 = healthy and 5 = complete defoliation. Means of five replications.

<sup>2/</sup> Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

REACTION OF FIVE SUGARBEET CULTIVARS TO INOCULATION  
WITH FIVE ISOLATES OF RHIZOCTONIA SOLANI IN THE FIELD

Experiment R-1

E. G. Ruppel

The interaction of five sugarbeet cultivars and five root isolates of Rhizoctonia solani was tested in a randomized complete block design with five replications in the field at Fort Collins. Lines and isolates are given in Table 1. One-row plots were 20 feet long and 22 inches apart. Inoculations were made on July 27, 5 weeks after thinning, using the rosette method with dry, ground barley-grain inoculum. All roots were dug by hand and rated for root rot severity on September 27. The ratings were based on a scale of 0 to 7, with 0 = healthy and 7 = dead. A mean disease index (D.I.) was calculated for each plot. Percentage healthy beets was calculated by combining sugarbeets in classes 0 and 1. Disease class 1 consisted of roots with small, inactive crown lesions. Hence, these roots were considered to be essentially healthy. Bliss' arcsine transformation was used for analyses of percentage data.

Analyses of results (Table 1) indicated that all isolates were significantly different from each other as measured by disease severity and percentage healthy roots at harvest. Isolate D induced the most rot, whereas isolate E caused the least severe reaction in any cultivar. Differences in disease indexes among most cultivars also were significant. The ranking and mean D.I. of cultivars in increasing disease severity were as follows: FC 701/4 (D.I. = 1.2); FC 702/4 (D.I. = 1.7); a Rhizoctonia resistant selection from SP 5831-0 (D.I. = 2.0); C 817 (D.I. = 3.3); and GW 674-56C (D.I. = 3.7). Disease indexes of FC 702/4 and the resistant selection from SP 5831-0 were not significantly different from each other. The cultivar x isolate interaction in the D.I. analysis also was statistically significant, probably due to the reversal in the ranking of cultivars C 817 and GW 674-56C inoculated with isolate C (Table 1). However, a separation analysis of interaction means indicated that the difference in D.I. between these lines was not significant. Thus, the interaction is considered to be biologically unimportant.

Percentage healthy roots of the cultivars was inversely proportional to disease severity. Only cultivars C 817 and GW 674-56C were not significantly different from each other. Mean percentages of healthy roots for the cultivars were as follows: FC 701/4 (77%); FC 702/4 (62%); Rhizoctonia resistant selection from SP 5831-0 (53%); C 817 (27%); GW 674-56C (23%). The cultivars x isolates interaction in this case was nonsignificant.

Greenhouse tests (1) and reports of other cooperators indicate that resistance of sugarbeet lines selected at Fort Collins apparently is effective against several highly pathogenic isolates of R. solani. Results reported herein support this contention.

Literature Cited

(1) Ruppel, E. G. Correlation of cultural characters and source of isolates with pathogenicity of Rhizoctonia solani from sugar-beet. *Phytopathology* (In press)

Table 1. Reaction of five sugarbeet cultivars to inoculation with five root isolates of Rhizoctonia solani in the field.

Isolate <sup>1/</sup>	Cultivar <sup>2/</sup>	D.I. <sup>3/</sup>	% Healthy <sup>4/</sup>
A	FC 701/4	1.4	70.6
	FC 702/4	2.1	51.0
	Rhiz. Res.	2.3	47.0
	C 817	3.5	17.6
	GW 674-56C	4.6	8.3
General mean <sup>5/</sup>		2.8 b	38.9 d
B	FC 701/4	1.1	80.5
	FC 702/4	1.7	64.2
	Rhiz. Res.	1.8	55.6
	C 817	3.3	21.4
	GW 674-56C	3.5	22.0
General mean		2.3 c	48.7 c
C	FC 701/4	0.8	90.8
	FC 702/4	1.6	68.4
	Rhiz. Res.	1.6	60.6
	C 817	3.1	29.1
	GW 674-56C	2.7	37.4
General mean		2.0 d	57.3 b
D	FC 701/4	2.3	45.6
	FC 702/4	2.4	39.8
	Rhiz. Res.	3.3	22.3
	C 817	4.8	6.5
	GW 674-56C	5.2	3.5
General mean		3.6 a	23.5 e
E	FC 701/4	0.5	96.8
	FC 702/4	0.9	88.0
	Rhiz. Res.	1.0	77.2
	C 817	1.8	59.3
	GW 674-56C	2.5	42.0
General mean		1.3 e	72.7 a

- 1/ Source of isolates: A) Ft. Morgan, Colo., 1969; B) Brighton, Colo., 1969; C) Platteville, Colo., 1968; D) B-6, standard isolate used for several years at Ft. Collins; E) Ft. Collins, Colo., 1959.
- 2/ Rhizoctonia resistant cultivars FC 701/4 and FC 702/4 represent six cycles of selection from susceptible cultivars GW 674-56C and C 817, respectively. Rhiz. Res. = Rhizoctonia resistant selection from SP 5831-0.
- 3/ Based on a scale of 0 to 7, with 0 = healthy and 7 = dead; means of five replications.
- 4/ Disease classes 0 and 1 (only small, arrested crown lesions) combined to calculate percentage healthy beets at harvest. Bliss' arcsine transformation was used for the analysis of variance and Duncan's multiple range test. Means of five replications.
- 5/ General means followed by the same letter in vertical columns are not significantly different at the 5% level according to Duncan's multiple range test.

SIDE DRESS VERSUS ROSETTE METHOD OF INOCULATING SUGARBEETS  
WITH RHIZOCTONIA SOLANI IN THE FIELD

Experiment R-2

E. G. Ruppel and J. O. Gaskill

A split plot design was used to compare side-dress application of inoculum at two dates and two rates with the rosette method of inoculating field-grown sugarbeets with Rhizoctonia solani (isolate R-9 [= B-6]). Main plots (treatments) consisted of two 20-foot rows 22 inches apart replicated six times. Each main plot was divided into two subplots consisting of one row each of resistant cultivar FC 701/4 and susceptible cultivar GW 674-56C. Dry, ground barley grain inoculum was used throughout. Treatments included: 1) side dress application of 12 cc inoculum per row 1 week after thinning (July 1); 2) side dress of 24 cc/row 1 week after thinning; 3) side dress of 12 cc 3 weeks after thinning (July 15); 4) side dress of 24 cc 3 weeks after thinning; 5) 0.7 cc inoculum in each crown at about 5 weeks after thinning (rosette); 6) noninoculated controls. Side-dressed inoculum was applied about 3 inches from the row and about 1 inch deep with a 'Planet Jr.' belt seeder. Beets were dug by hand on September 28 and rated individually for root rot severity. The ratings were based on a scale of 0 to 7, with 0 = healthy and 7 = dead. A mean disease index (D.I.) was calculated for each subplot. Percentage healthy beets was calculated by combining roots in classes 0 to 1. Beets in class 1 were considered essentially healthy because only small, inactive lesions were observed in their crowns. Bliss' arcsine transformation

Table 1. Comparison of side-dress inoculation at two dates and two dosages with the rosette method of inoculation of resistant cultivar FC 701/4 and susceptible cultivar GW 674-56C with Rhizoctonia solani in the field.

Inoculation <sup>1/</sup> method	Cultivar	Disease <sup>2/</sup> index	% Healthy <sup>3/</sup>
SD-1-L	GW 674-56C	5.0	17.0
	FC 701/4	3.4	34.4
	General mean <sup>4/</sup>	4.2 bc	25.7 b
SD-1-H	GW 674-56C	6.8	0.0
	FC 701/4	5.4	13.1
	General mean	6.1 a	6.5 d
SD-3-L	GW 674-56C	4.4	26.6
	FC 701/4	2.5	51.2
	General mean	3.5 cd	38.9 a
SD-3-H	GW 674-56C	6.1	4.2
	FC 701/4	3.9	25.7
	General mean	5.0 b	15.0 c
Rosette	GW 674-56C	3.9	17.3
	FC 701/4	1.6	65.6
	General mean	2.8 d	41.5 a
Control	GW 674-56C	0.0	100.0
	FC 701/4	0.0	100.0
	General mean	0.0	100.0

<sup>1/</sup> SD = side dress; 1 and 3 = 1 and 3 weeks after thinning; L = light rate, 36 cc/20 ft row; H = heavy rate, 72 cc/20 ft row; rosette = 12 cc/plant. Dry, ground barley grain inoculum of R. solani (isolate R-9 [=B-6]) used throughout.

<sup>2/</sup> Based on a scale of 0 to 7, with 0 = healthy and 7 = dead; means of six replications.

<sup>3/</sup> Disease classes 0 and 1 combined. Bliss' arcsine transformation used for analyses. Means of five replications.

<sup>4/</sup> General means followed by the same letter in vertical columns are not significantly different at the 5% level according to Duncan's multiple range test.

was used for analyses of percentage data. Due to the lack of variability, data from noninoculated plots were not included in the statistical analyses.

Analyses of data indicated that differences in D.I. and % healthy roots among treatments and between lines were highly significant. The treatments x lines interaction was nonsignificant in both analyses. The results (Table 1) demonstrated that side dressed inoculum at a rate of 12 cc/20-ft row 3 weeks after thinning (SD-3-L) was as effective as the rosette method for initiating a root rot epidemic in our nursery. Other treatments were considered too severe to permit adequate contrasts between resistant and susceptible cultivars.

The side-dress technique, as compared to the rosette method, is characterized by its simplicity and low cost; however, its reliability must be tested over several seasons under local conditions. Presently, we are considering using side-dress inoculation in most of our field experiments. In selection blocks, where it is imperative to avoid disease escapes, the rosette method will be retained.

#### EFFECT OF BENOMYL IN CONTROLLING ROT OF STORED SUGARBEET ROOTS

E. G. Ruppel and J. O. Gaskill

Each year a certain amount of rot occurs in our mother beets stored under cool temperatures and high relative humidity. Fungi involved usually include Botrytis, Fusarium, and Phoma spp. An attempt was made to control storage rot with benomyl dips to prevent the loss of valuable breeding material.

Roots of sugarbeet cultivar SP 5822-0, harvested from our Cercospora disease nursery in October 1970, were immersed for 1 minute in mixtures of benomyl (50% WP) at 0, 1/8, 1/4, 1/2, or 1 pound active ingredient per gallon of water. Each mixture contained 4 oz/100 gallon of a surfactant. Storage crates also were immersed. The roots were stored in crates (40/crate) in our root-storage room at 4 C and 100% relative humidity. In May 1971, each beet was assigned a disease rating of 0 to 4, with 0 = no rot and 4 = 100% rotted. A randomized block design was used with four replications (crates) of each treatment.

Benomyl was ineffective in controlling sugarbeet storage rot under our conditions. Although differences among treatments were not significant, there was a definite trend toward increased rot with an increase in benomyl concentration. Mean disease indexes at each concentration of benomyl were as follows: 0 = 0.71; 1/8 lb = 0.74; 1/4 lb = 0.82; 1/2 lb = 0.90; and 1 lb = 1.06.

## LEAF SPOT AND CURLY TOP RESEARCH 1971

G. A. Smith and E. G. Ruppel

Although some changes in the LSR-CTR program at Fort Collins are envisioned with the retirement of Mr. John O. Gaskill, evaluation and development of LSR-CTR, monogerm, Type-0 lines and their male sterile equivalents will continue. The cooperative agronomic and disease resistance tests conducted by Federal, State and sugar company research personnel, which has been so valuable, will continue. Increased emphasis will also be given to studies on the nature of disease resistance in sugarbeet, and the relationship between resistance to leaf spot and resistance to curly top. Studies will be conducted to determine what level of resistance to each disease can be expected in the same line. Some evidence currently suggests that only a moderate degree of resistance to both diseases is possible in the same line. Cooperative efforts between the Fort Collins and Logan, Utah stations should provide information on this relation.

Methods of rapidly and economically determining general and specific combining ability are currently being investigated. We will also investigate the quantitative production of anti-fungal compounds (phytoalexins) by sugarbeet lines as a means of determining disease resistance in breeding material. Preliminary work has indicated that phytoalexin production is positively correlated with degree of leaf spot resistance in sugarbeet (D. D. Maag and G. Johnson, CSU Chemistry Department, personal communication).

The use of highly resistant CTR lines such as L-35 and L-36 from Sugarbeet Investigations, ARS, Logan, Utah, in many crosses will be emphasized in expanding our germplasm base.

Segregating populations of Beta procumbens-vulgaris hybrids furnished by Drs. E. D. Whitney and Helen Savitsky, sugarbeet Investigations, Salinas, California, were grown and selected under leaf spot conditions in the field. Polycrossed seed from plants selected under field leaf spot conditions in 1970 was obtained in the greenhouse in 1971 and will be grown under field leaf spot conditions for further selection in 1972. The resistance represented in these populations may be a new source of resistance to Cercospora.

THE ASSOCIATION OF CERCOSPORA LEAF SPOT, GROSS SUGAR,  
PERCENT SUCROSE AND ROOT WEIGHT

G. A. Smith

The effect of severe leaf spot in the field on the incidence of subsequent rots of sugarbeet roots during storage has recently been reported (2). Cercospora was found to be a predisposing factor in storage rot of sugarbeets.

The study reported here was designed to determine the quantitative effect of varying degrees of leaf spot on several sugarbeet characters. Leaf spot reading, percent sucrose analyses, and root weight determinations were taken on 488 individual roots from three  $F_2$  populations segregating for leaf spot resistance. Two of the populations were from resistant x susceptible crosses and one was from a susceptible x susceptible cross. All three populations were grown under artificially induced leaf spot conditions and were harvested 130 days after planting. The severe leaf spot epidemic and short growing period account for the general low sucrose and root weights. It would, however, be expected that the same patterns as found in this study would occur with beets grown for a longer period of time. The results for the three crosses are seen in Table 1. Increased intensity of leaf spot was followed by a reduction in gross sucrose. A distinct and significant reduction in gross sucrose was apparent between class 2 and the other less resistant classes (3 thru 9). Saito (1) reported that a single unit increase in the leaf spot index resulted in a 10-23% decrease in gross sugar and a 1-5% decrease in sugar content. Our results generally agree with those of Saito except that a leveling off was found from class 3 thru 6. Reductions in gross sucrose with increasing leaf spot severity were due more to reduction in sucrose percent than to a reduction in root weight up to leaf spot class 7. From classes 7 thru 9 reductions in gross sucrose appear to have been due more to reduction in root weight than to reduced sucrose percent, although low numbers of roots in these susceptible classes may give a false impression.

Further research now in progress should determine the relation between storage rot, leaf spot degree and percent sucrose.

Literature Cited

- (1) Saito, K. 1966. Studies on the Cercospora leaf spot resistance in sugarbeet breeding. Mem. Fac. Agr. Hokkaido Univ. (Japan) 6: 113-179.
- (2) Smith, G. A. and E. G. Ruppel. 1971. Cercospora leaf spot as a predisposing factor in storage rot of sugar beet roots. Phytopathology 61: 1485-1487.

Table 1. The effect of Cercospora leaf spot on percent sucrose root weight, gross sucrose and the percent reduction with increased leaf spot.

Leaf spot class <sup>1/</sup>	Mean sucrose %	% Reduction from class 1	Mean root wt. g.	% Reduction from class 1	Sugar in gms. per root	% Reduction from class 1
1	9.30 a <sup>2/</sup>		385.8 a		36.22 a	
2	8.83 a	5.0	332.5 ab	13.8	32.07 a	11.5
3	7.06 b	24.0	300.6 b	22.0	23.47 b	35.2
4	6.31 b	32.0	317.5 ab	17.7	23.15 b	36.1
5	6.48 b	30.3	314.3 ab	18.5	22.10 bc	39.0
6	6.79 b	26.9	292.4 bc	24.2	21.51 bc	40.6
7	6.80 b	26.8	246.6 c	36.0	18.58 c	48.7
8	6.45	30.6	250.0	35.2	19.84	45.2
9	5.80	37.6	225.0	41.7	13.05	64.0

<sup>1/</sup> Leaf spot grades based on the scale 0 = healthy and 10 = complete defoliation.

<sup>2/</sup> Means followed by the same letter are not significantly different; classes 8 and 9 were not included in the statistical analyses due to low n numbers.

SUGARBEET LEAF AMINO ACIDS AND THEIR RELATION  
TO CERCOSPORA LEAF SPOT RESISTANCE

G. W. Maag, D. M. Rasmussen, R. J. Hecker, and P. A. Whitaker

This experiment was designed to detect relationships of individual leaf amino acids and other ninhydrin positive compounds with Cercospora leaf spot resistance in sugarbeet. Preliminary experiments were conducted in 1968 and 1969, and previously reported. Following the survey experiments of 1968 and 1969, it became apparent that there were no obvious or gross relationships of leaf amino acids with leaf spot resistance which were detectable by studying means. Therefore, we decided to conduct a replicated experiment in 1970 on which a more sophisticated analysis could be conducted.

Materials and Methods

The experimental material consisted of the six varieties (three leaf spot susceptible and three resistant) described below. They were grown in three replications at both the Colorado State University Agronomy Research Center and the Disease Farm Nursery at Fort Collins, Colorado.

Entry no.	Population	Description
1	52-334	Highly LSS, inbred, low vigor
2	R & G Pioneer	LSS, heterogeneous
3	US H9B	LSS, 3-way commercial hybrid
4	US 201	LSR, relatively heterogeneous
5	SP 5822-0	LSR, heterogeneous
6	FC(504x502/2) x SP 6322-0	LSR, 3-way hybrid

Plants at the Disease Farm were inoculated with Cercospora beticola on July 6, 1970. Leaves were harvested three times at each location during the summer of 1970 (July 31, August 10, and August 19) as the infection progressed on the inoculated plants. The harvests were made in the morning on each date from each location and as near the same time as possible. One middle-aged fully expanded leaf was selected from each plant of each plot to make a single sample for the plot. The samples were transferred to the laboratory as soon after harvest as possible. The samples for amino acid analysis were prepared and frozen until time of analyses on the Technicon amino acid analyzer.

The quantities of individual amino acids were converted to a dry leaf weight basis instead of a fresh leaf weight basis as in the previous years. This should reduce the variability due to differences in

moisture content and the effect of necroses.

Quantitative determinations were made of the following 22 amino acids (or groups) and other ninhydrin positive compounds: aspartic acid (asp), threonine (thr), serine-glutamine-asparagine (ser-gln-asn), glutamic acid (glu), glycine (gly), alanine (ala), valine (val), methionine (met), isoleucine (ile), leucine (leu), 3,4 dihydroxyphenylalanine (dopa), tyrosine (tyr), phenylalanine (phe), gamma-aminobutyric acid (gaba), ornithine (orn), lysine (lys), histidine (his), tryptophan (try), arginine (arg), citrulline (cit), and pipecolic acid (pip).

#### Results and Discussion

Noninoculated Experiment: The main question of concern from the disease free experiment was: "Are there one or more amino acids that might be related to *Cercospora* leaf spot resistance or susceptibility?" To answer this question a statistical analysis was made of each amino acid for each of the three harvest dates. Thus, 66 different F tests were made. The one degree of freedom linear contrast of susceptible versus resistant varieties was calculated for each of the above tests where the differences between varieties were significant at the 5% level. Using the linear contrast F test, we found 17 were significant on the first harvest date, seven on the second, and 12 on the third. Glu, dopa, his, and the ser-gln-asn combination were significant at the 5% level on all three dates. All possible combinations of significant and nonsignificant contrasts were observed over the three harvest dates. No relationship between any sub-set within the 22 amino acids and disease resistance could be found.

Another approach was needed. The technique of discriminant analysis was used next. The varieties were grouped into two natural groupings, susceptible and resistant. All the data were pooled for the three dates.

Discriminant analysis is a multivariate technique used to study the extent that different populations or classes interrelate or diverge from one another. It has three principal uses: 1) classification, 2) study of the relations between different groups, and 3) as a multivariate generalization of the t-test. We were interested in the second use. The idea was to determine a linear function based upon all or part of the responses that were measured such that when the function was evaluated the observation could be assigned to one or the other of the groups with minimum probability of misclassification.

To determine which responses were important, a step-wise discriminant analysis computer program was used. As a first step, this program picked out the most important variable based upon an F test as the criterion for selection. In the second and succeeding steps, the variable entered was the one that maximized the criterion, adjusted for the variables already in the function. The following amino acids

were found to be the important ones: dopa, glu, gly, ser-gln-asn, and val (given in the order that they entered the discriminant function). They provided a possible set of amino acids that differed between the susceptible and resistant varieties.

The next question was, "Can the above set of five amino acids be reduced to one or two?" This question was answered by using a test that determined if there was information left in a remnant set of variables. It reduced to an F test. The test was run on dopa alone, and we found there was information in the remaining 21 amino acids. Next, the test was made on dopa and glutamic acid. The test indicated there was no significant information in the remaining 20 amino acids.

The question asked next was, "Will any other amino acid, besides glutamic acid, yield an equal or greater level of significance with dopa?" The answer to this question was no. The step-wise discriminant analysis had identified those variable which maximized the information, and the only discriminant set among the amino acids was dopa and glutamic acid. The final discriminant function was:

$$\lambda = .00014X_1 - .00363X_2$$

where  $X_1$  is the determination of glutamic acid in the sample, and  $X_2$  is the determination of dopa. The function could be used to classify any other population into either the susceptible or resistant group, depending upon the value of  $\lambda$  obtained. The rule is to classify the population to the susceptible group if  $\lambda > C$ , otherwise classify it to the resistant group. The constant  $C$  is the mean of the susceptible and resistant groups from which the discriminant function had been developed.

The amino acids, dopa and glutamic acid, are quite different from each other biochemically. This could partially account for the information being maximized by them. These two amino acids provided the only really significant information in this study differentiating between the resistant and susceptible genotypes. It was impossible to determine the discriminant variables solely from an examination of means, graphs, or correlations. However, after discriminant analysis, it was useful to examine graphs of important variables. The means displayed in Figure 1 indicated that dopa differentiated between LSR and LSS groups, particularly in leaves harvested July 31. Figure 2 indicated that glutamic acid differentiated best in leaves harvested August 17. These were inherent or pre-existing conditions which were related or linked only to the LSR and LSS genotypes themselves. The quantity of these compounds was in no way a response reaction to the pathogen. Historically, the search for pre-existing compounds related to resistance has been the main approach in trying to relate individual compounds to disease resistance. This was enhanced by the classic success connecting onion smudge resistance with two related phenolic compounds. Our experiment was one of this nature. Actually, however,

few good cases of pre-existing compounds conditioning resistance have been demonstrated. Currently the phytoalexins appear to show more promise for disease resistance evaluation in plants. The phytoalexins are specific compounds which are synthesized by the plant, primarily as a response reaction to the presence of a specific pathogen.

At this point we are unable to explain how the quantity of free glutamic acid in leaf spot-free leaves of sugarbeet is related to leaf spot resistance. Further, even though glutamic acid is a significant determinant in the discriminant function, its relation by itself to resistance does not appear to be consistent enough or sufficiently discriminating to serve as a means for population evaluation.

Dopa appears to show similar relationships with resistance as its decarboxylation product, 3-hydroxytyramine, which we have studied in previous years, 3-hydroxytyramine (dopamine) is a ninhydrin negative compound and is not measured in the amino acid analysis. Although we have not measured dopa in a wide range of genotypes, we suspect it may show quantitative exceptions in its relation to resistance, as did 3-hydroxytyramine.

Inoculated Experiment: Parallel analyses were performed on the data from the Disease Farm. Again the individual F tests did not yield conclusive results. Twelve of the linear contrast F tests were significant on the first harvest date, only two on the second, and nine on the third. Cystine and phenylalanine were the only two amino acids significant on all three harvest dates. A discriminant analysis was run similar to the one for the disease-free location. Variables entered were cys, pip, ser-gln-asn, lys, his, and met in that order. Using the test to determine which subset of these was minimal, it was found that the first four were sufficient. The discriminant function in this case was very different from the one determined from the data of healthy plants. Since cys, pip, ser-gln-asn, and lys all provided significant discriminating information, yet by studying the means none of these could be identified as a response reaction, this discriminant function appeared to provide little help toward resistance classification. It would seem less likely that a consistently accurate function could be developed from data of diseased plants than from data of healthy plants. This conclusion was developed from the study of our data and from the fact that the free amino acid content of sugarbeet leaves is probably very labile with changes taking place in response to any physiological stress. Some of these stresses might lead to responses just like leaf spot infection.

Pooled Data: After the individual analyses at each location had been done, they were then pooled to determine if there were any amino

acids that reacted the same in both environments. Information for this was obtained by looking at the interaction between varieties and locations (environments). Using the F test of varieties, it was found that 18 amino acids were significant on the first harvest date with 17 significant linear contrasts; 15 were significant on the second date with four significant linear contrasts; and on the third date, 15 were significant with 15 significant linear contrasts.

There were six significant interactions with three linear contrasts significant on the first date, 11 significant interactions on the second date with six significant linear contrasts, and 10 significant interactions with nine significant linear contrasts on the third harvest date.

It was not possible to do an analysis combining all dates and locations (or even the dates within a location) because the responses measured on the three dates were correlated.

Lysine was the only amino acid that was significant on all three dates for the interaction and the interaction linear contrast. Gly, ala, ile, tyr, phe, his, and cit were significant for varieties for all three dates. Cit, his, and phe were the only amino acids that had significant linear contrasts on all three dates.

A discriminant function was not computed for the pooled data. The dispersion matrix included such great unidentifiable differences that it was not considered worth while to develop the function.

### Discussion

Ideally a discriminant analysis would develop a function into which values from unknown populations could be inserted and then classified as resistant or susceptible. In our case, we do not have an empirical test of our discriminant functions to see how well they would classify populations other than those six used to develop the function. We are now at a point of having to decide whether it is worth conducting a larger experiment to make this empirical test, or whether other avenues might be more fruitful; another promising avenue is classification of populations on the basis of the post inoculation quantities of the phytoalexins which have been discovered by Drs. D. D. Maag and G. Johnson at Colorado State University.

As an aid in evaluating our discriminant function without going to a large empirical test, in 1971 we conducted an experiment using the same populations as in 1970, but we harvested leaves only from three individual plants in each plot of each replication. Unfortunately, the disease free test was hailed and lost prior to leaf harvest. The purpose of this experiment was to determine the magnitude of individual

plant variability in relation to our discriminant functions. We had hoped to be able to decide from this experiment whether our discriminant functions were worth a large empirical test. Since only the diseased part of the experiment survived, we are left without a good basis for deciding whether to investigate further the utility of our best function. However, we feel at this time, that we will hold this discriminant approach in abeyance in favor of work with the phytoalexins.

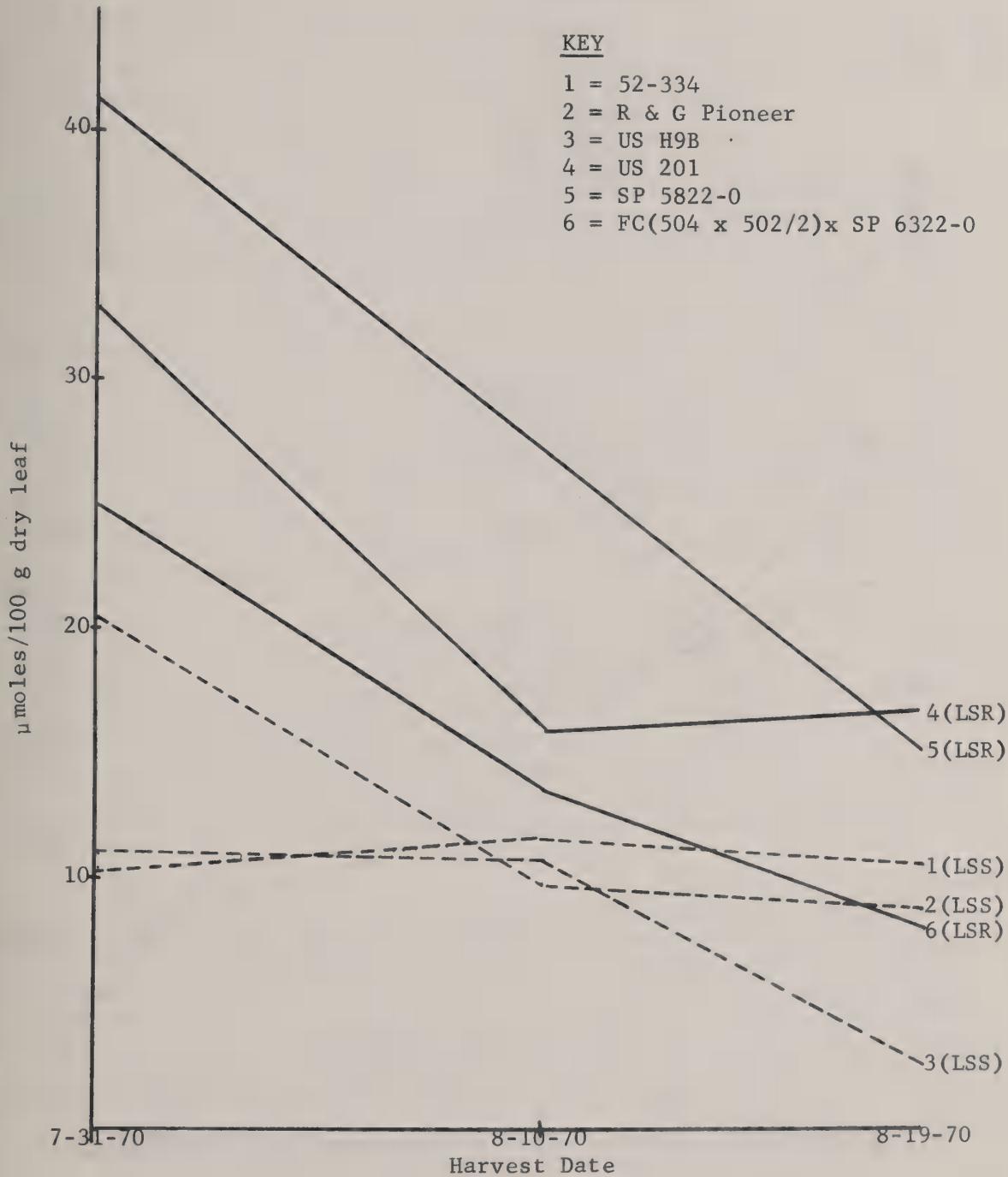


Fig. 1. Dopa in leaves of healthy sugarbeet plants, 1970.

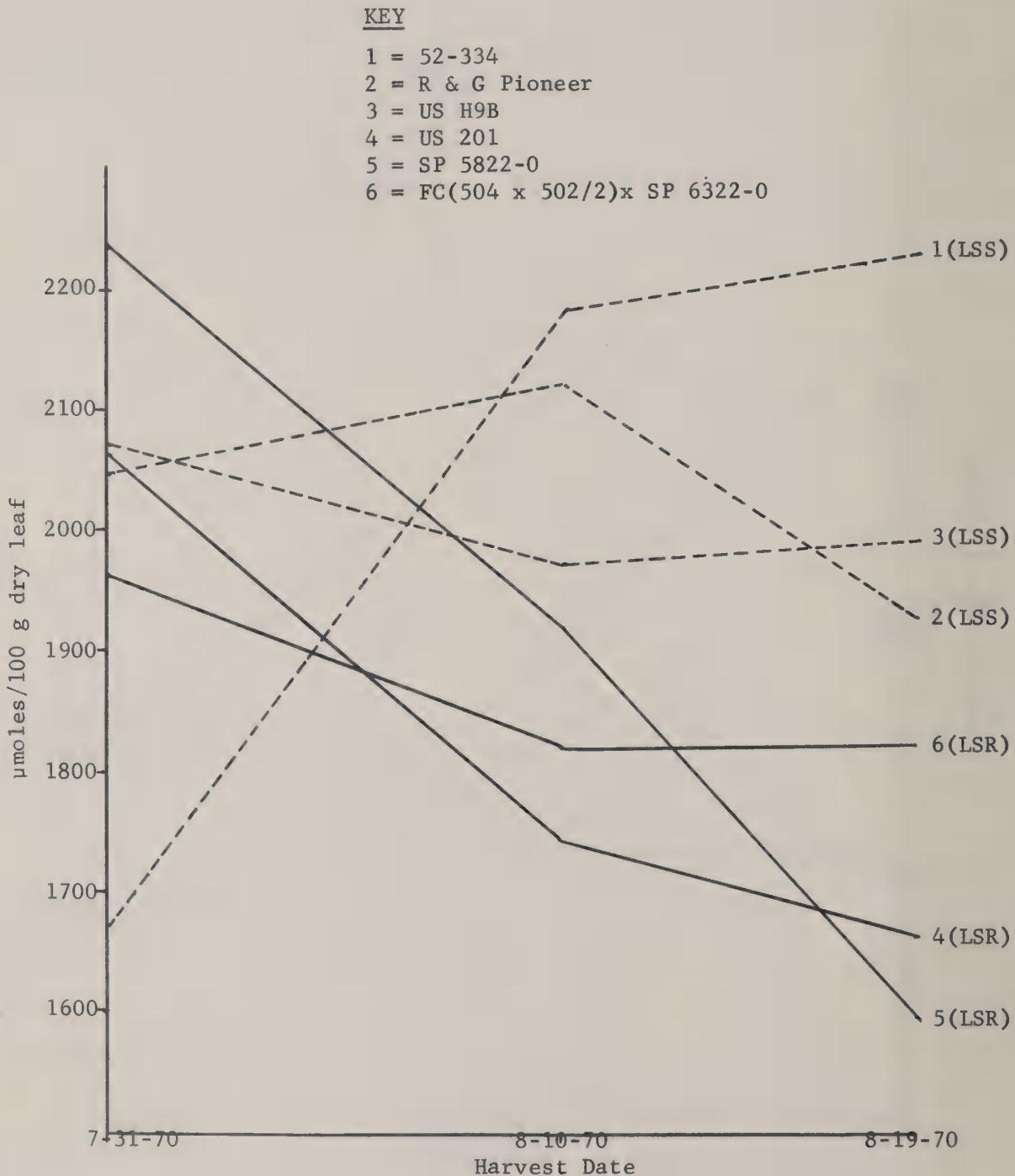


Fig. 2. Glutamic acid in leaves of healthy sugarbeet plants, 1970.

COOPERATIVE TESTS OF LSR-CTR VARIETIES

G.A. Smith, E.G. Ruppel, R.J. Hecker, and Cooperators

The varieties described in Table 1 were evaluated by federal, state, and sugar company research personnel in several states in 1971. Reports for the individual agronomic tests are presented in Tables 6 through 16.\*\* Summaries of available agronomic data are presented in Tables 2 through 4 and disease data summaries are presented in Table 5.

The CTR check (entry number 8, US H9B) produced low sucrose yields under leaf spot conditions but did fair under locations reporting negligible leaf spot. The LSR check [entry number 7, FC(504 x 502/2) x SP 6322-0] yielded above the standard variety US H20 (entry 1) under leaf spot conditions and below US H20 under negligible leaf spot conditions. Entry number 3, FC 506 x FC 903 produced the highest gross sucrose yield under leaf spot conditions and had the second highest average under negligible leaf spot. The improved leaf spot resistance of FC 903 versus FC 901 is demonstrated by the 11% difference in sucrose yield between entry 2 and entry 3 (Table 2). FC 903 is a leaf spot resistant selection from FC 901. The difference between entry numbers 4 and 5 were their respective pollinators FC 903 and McF 413. Entry number 4 with FC 903 as the pollinator averaged slightly higher than entry 5 with McF 413 as pollinator for sucrose yield and root weight in the presence or absence of leaf spot. For sucrose percentage, both entries performed about equal.

Entry number 6 with the Rhizoctonia resistance pollinator FC 701/2 had the highest average sucrose percentage under leaf spot and non-leaf spot conditions. At every location except Beltsville, Maryland, entry 6 rated 1-17% better than the standard check US H20 for percent sucrose. The genetic potential of the entries is indicated to some extent by the Farmington, New Mexico test (Table 7). Gross sucrose for the eight entries ranged from 10,111 pounds per acre to 12,778 pounds per acre. This is an area in which sugarbeets have been grown only two years. The area is considered pest free.

Curly top was not a factor again this year in any of the agronomic tests summarized in Tables 2 through 4. A summary of curly top grades from Logan, Utah is presented in Table 5. A narrow range in entries is indicated for the 8 entries. It should be noted that entry 8 which served as a CTR check is recognized as having substantial resistance and in this test did show the highest resistance of all entries. Entry 7, the LSR check, is recognized as being curly top susceptible and did show more susceptibility than entry 8. Since this difference was not great in this test, small differences in mean curly top grade may represent substantial differences in actual resistance.

A comparatively wide range in leaf spot resistance among entries 1 through 8, is shown in Table 5. As expected, the CTR check (entry 8)

was the most susceptible. The LSR check entry 7 was next to the most resistant entry 6. It is encouraging to note that entry 6 which probably has some Rhizoctonia resistance, maintained a high level of resistance to leaf spot. The standard variety US H20 (entry 1) was next to the last entry 8 in resistance to leaf spot. All other entries (2 through 6) were significantly more resistant than entry 1.

The leaf spot and curly top grades of twelve miscellaneous lines evaluated for leaf spot at Fort Collins and for curly top at Logan, Utah, are presented in Table 17. This table is especially useful in comparing several pollinators crossed to a common female line.

Table 1. Description of material in cooperative evaluation tests of LSR-CTR varieties, 1971<sup>1/</sup>.

Entry no.	Fort Collins seed no.	Description
1	Acc. 2707	US H20 [SL(129 x 133) x SP 6322-0]; monogerm; LSR-CTR-BRR; furnished by F & M.
2	SP 691202H02	FC 506 x FC 901; monogerm; LSR-CTR.
3	SP 701203H02	FC 506 x FC 903; monogerm; LSR-CTR.
4	SP 701203H06	[FC(504 x 502/2) x SP 652016s1] x FC 903; monogerm; LSR-CTR.
5	SP 701206H06	[FC(504 x 502/2) x SP 652016s1] x McF 413; monogerm; LSR-CTR; probably some yellows resistance.
6	SP 701207H07	(SP 632028s1 x FC 601) x FC 701/2; monogerm; LSR-CTR, probably some <u>Rhizoctonia</u> resistance.
7	SP 701201H03	FC(504 x 502/2) x SP 6322-0; monogerm; <u>LSR check</u> .
8	Acc. 2771	US H9B; monogerm; <u>CTR check</u> ; virus yellows resistant; bolting resistant.

1/ In addition to these varieties, one or more "local checks", furnished by the cooperators, were included in the tests as indicated on the respective tables of results.

2/ LSR = Cercospora leaf spot resistant; CTR = Curly top resistant; BRR = black root resistant or Aphanomyces-type black root resistance.

\*\*NOTE: Data in Tables 18 and 19 was received at press time and is not included in summary tables 2 through 4.

Table 2. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1971; as percentage of the standard variety, US H20 (Acc. 2707, Entry 1).

Test no., State, and locality	No. of reps	1/ Leaf spot	2/ Relia- bility	Entry no.				3/ LSD (.05)
				1	2	3	4	
(1)AZ, Willcox	6	3	ex	100	84	100	98	95
(2)CO, Fort Collins	8	3	vs	100	111	117	122	115
(3)CO, Longmont	6	0	vg	100	102	96	104	98
(4)CO, Rocky Ford	4	0	g	100	87	77	75	73
(5)CO, Two Buttes	4	0	g	100	108	108	108	105
(6)KS, Garden City	4	0	g	100	91	107	98	100
(7)KS, Ulysses	4	0	ex	100	118	120	112	101
(8)MD, Beltsville	3	2	s	100	115	133	116	107
(9)NM, Farmington	5	0	ex	100	109	103	111	107
(10)TX, Hereford	9	1	s	100	86	91	92	102
Avg.-Negligible leaf spot (3,4,5,6,7,9)				100.0	102.5	101.8	101.3	97.3
Avg.-Apparent to severe leaf spot (1,2,8,10)				100.0	99.0	110.3	107.0	104.8
								105.3
								89.0

Note: Local checks varied between cooperators and partial descriptions can be found on each cooperators summary table.

1/ Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

2/ Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

3/ LSD (.05) expressed as percent of sucrose yield of the standard variety (entry no. 1).

Table 3. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1971; as percentage of the standard variety, US H20 (Acc. 2707, Entry 1).

Test no., State, and locality	No. of reps	Leaf spot	Relia- bility	Beet Yield				Entry no.				LSD <sup>3/</sup> (.05)
				1	2	3	4	5	6	7	8	
(1)AZ, Willcox	6	3	ex	100	85	101	104	98	81	93	103	15
(2)CO, Fort Collins	8	3	vs	100	100	107	111	104	131	86	104	13
(3)CO, Longmont	6	0	vg	100	100	95	98	98	99	83	97	--
(4)CO, Rocky Ford	4	0	g	100	88	82	81	78	82	78	95	15
(5)CO, Two Buttes	4	0	g	100	107	107	105	104	96	103	103	13
(6)KS, Garden City	4	0	g	100	89	100	92	95	98	99	97	17
(7)KS, Ulysses	4	0	ex	100	116	121	113	102	99	107	107	8
(8)MD, Beltsville	3	2	s	100	112	132	119	112	88	129	86	32
(9)NM, Farmington	5	0	ex	100	108	103	112	111	87	89	113	14
(10)TX, Hereford	9	1	s	100	83	87	86	94	84	91	98	9
Avg.-Negligible leaf spot (3,4,5,6,7,9)				100.0	101.3	100.2	98.0	93.5	93.2	102.0		
Avg.-Apparent to severe leaf spot (1,2,8,10)				100.0	95.0	106.8	105.0	102.0	96.0	99.8	97.8	

Note: Local checks varied between cooperators and partial descriptions can be found on each cooperators summary table.

1/ Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

2/ Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

3/ LSD (.05) expressed as percent of beet yield of the standard variety (entry no. 1).

Table 4. Summary of available harvest results, cooperative agronomic evaluation tests of LSR-CTR varieties, 1971; as percentage of the standard variety, US H20 (Acc. 2707, Entry 1).

Sucrose Percentage

Test no., State, and locality	No. of reps	Leaf spot	Relia-bility	Entry no.				LSD (.05)
				1	2	3	4	
(1) AZ, Willcox	6	3	ex	100	99	99	96	107
(2) CO, Fort Collins	8	3	vs	100	111	109	110	117
(3) CO, Longmont	6	0	vg	100	102	102	106	106
(4) CO, Rocky Ford	4	0	g	100	99	94	93	101
(5) CO, Two Buttes	4	0	g	100	101	102	104	101
(6) KS, Garden City	4	0	g	100	103	106	105	105
(7) KS, Ulysses	4	0	ex	100	102	99	99	106
(8) MD, Beltsville	3	2	s	100	104	101	97	96
(9) NM, Farmington	5	0	ex	100	101	100	99	101
(10) TX, Hereford	9	1	■	100	103	105	108	108
Avg.-Negligible leaf spot (3,4,5,6,7,9)				100.0	101.3	100.5	101.2	99.0
Avg.-Apparent to severe leaf spot (1,2,8,10)				100.0	104.3	103.5	102.3	102.5
							105.8	105.0
								90.8

Note: Local checks varied between cooperators and partial descriptions can be found on each cooperators summary table.

1/ Leaf spot exposure: 0 = negligible; 1 = mild; 2 = moderate; 3 = severe. Other diseases were considered negligible in all tests.

2/ Cooperator's appraisal of test: g = good; vg = very good; ex = excellent; s = satisfactory; vs = very satisfactory.

3/ LSD (.05) expressed as percent of sucrose percentage of the standard variety (entry no. 1).

Table 5. Summary of disease resistance comparisons, cooperative tests of LSR-CTR varieties, 1971.

Entry Identification	Entry no.	Leaf spot grades <sup>1/</sup>			Curly Top <sup>2/</sup> Logan, Utah Field	Rhizoctonia <sup>4/</sup> D. I. <sup>3/</sup> Ft. Col. % H. Colo.	
		Ft. Col. Colo.	Belts. Md.	Avg			
Acc. 2707(US H20)	1	4.6	4.7	4.65	6.0	4.6	16.30
SP 691202H02	2	3.6	3.7	3.65	6.5	4.7	14.17
SP 701203H02	3	2.8	3.7	3.25	7.0	3.6	27.34
SP 701203H06	4	2.9	3.8	3.35	5.5	4.7	16.01
SP 701206H06	5	3.6	3.3	3.45	6.0	5.2	10.93
SP 701207H07	6	2.5	2.8	2.65	6.0	2.6	36.41
SP 701201H03	7	2.6	3.0	2.80	6.5	3.8	26.94
Acc. 2771(US H9B)	8	6.5	5.0	5.75	5.0	4.7	16.99
GW 674-56C		3.9			8.0	4.6	16.34
GW Mono Hi A-1		3.7			8.0	4.4	16.77
(68519-01 x 67550-0) x 6822-0 (B)				2.8			
LSD (.05)		.7	.8			.6	9.7

<sup>1/</sup> 0 = healthy; 10 = complete defoliation.

<sup>2/</sup> At Logan, Utah 0 = healthy, and 9 = dead.

<sup>3/</sup> 0 and 1 = essentially healthy; 7 = dead.

<sup>4/</sup> Percentage of beets classed as essentially healthy.

Table 6. Cooperative agronomic test of LSR-CTR varieties, 1971  
Location: Experiment Station Farm, Longmont, Colorado

Seed no. or variety	Entry no.	Acre yield			Plants per 100'
		Gross sucrose Lbs.	Beets Tons	Sucrose %	
Acc. 2707	1	4608	23.02	9.98	112.5
SP 691202H02	2	4707	22.97	10.17	100.6
SP 701203H02	3	4421	21.76	10.15	117.5
SP 701203H06	4	4778	22.49	10.57	110.3
SP 701206H06	5	4518	22.55	9.98	114.7
SP 701207H07	6	4829	22.80	10.60	107.7
SP 701201H03	7	3391	19.10	8.85	101.8
Acc. 2771	8	4222	22.24	9.44	111.5
GWH45	9	4925	20.53	12.04	112.5
GW761	10	4552	20.99	10.77	105.0
General mean		4496	21.84	10.26	109.5
CV (%)		12.85	10.45	6.27	---
LSD (.05)		672	N.S.	0.75	---

Conducted by: Great Western Sugar Co. (Alvin Erichsen, Akio Suzuki, and David Rademacher).

Dates of Planting and Harvest: Planted March 30, 1971; Harvested October 4, 1971.

Experimental Design (Including No. of Reps): Randomized Complete Block, 2 rows; 6 replications.

Determination of Beet Yield and Sucrose Percentage: All beets were harvested in a competitive-stand area (36 ft. of row) 18 ft. of each of two rows. Each sample was then topped, weighed, and analyzed for sugar.

Leaf Spot Exposure: Negligible.

Curly Top Exposure: Negligible.

Other Diseases and Pests: Field was fumigated for nematodes and treated for sugarbeet root maggot.

Reliability of Test and Remarks: Good test. Early freeze on September 27 damaged leaves.

Table 7. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Farmington, New Mexico.

Seed no. or variety	Entry no.	Acre yield			Plants per 100'
		Gross sucrose	Beets	Sucrose	
		Lbs.	Tons	%	No.
Acc. 2707	1	11,470	31.2	18.2	108
SP 691202H02	2	12,553	33.8	18.3	122
SP 701203H02	3	11,854	32.0	18.2	123
SP 701203H06	4	12,698	34.8	18.0	115
SP 701206H06	5	12,223	34.7	17.4	112
SP 701207H07	6	10,124	27.1	18.4	99
SP 701201H03	7	10,111	27.8	17.9	118
Acc. 2771	8	12,778	35.1	17.9	124
Holly Sugar Co.; HH-7	9	10,745	28.3	18.7	101
General mean		11,616	31.6	18.1	114
CV (%)		2.0	10.5	2.5	12.7
LSD (.05)		1,558	4.3	.6	N.S.

Conducted by: E. J. Gregory

Dates of Planting and Harvest: May 12, 1971; November 4, 1971.

Experimental Design (Including No. of Reps): Randomized block with 5 reps. Plots were 2-20 inch rows 15 feet long. Beets thinned to a 10 inch spacing.

Determination of Beet Yield and Sucrose Percentage: Yield taken by harvesting 10 feet in the middle of two 20 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Excellent. This was the second year of sugar beet testing on the station. The area is free of weed, disease and insect problems. Yields and sugar percentages are very high, due in part, at least, to the lack of sugar beet pests. The performance of this trial illustrates the capability of these varieties when grown in a sugar beet pest-free area.

Table 8. Cooperative Agronomic Test of LSR-CTR Varieties, 1971.  
Location: Warren Tract, Fort Collins, Colo. (Exp. 1A).

Seed no. or variety	Entry no.	Acre yield		Sucrose	Plants per 100 <sup>1</sup>	Leaf spot	Thin Juice Purity
		Gross sucrose	Beets				
		Lbs.	Tons	%	No.	%	%
Acc. 2707	1	2016	9.65	10.46	110	4.6	89.28
SP 691202H02	2	2233	9.66	11.56	105	3.6	90.86
SP 701203H02	3	2365	10.35	11.42	104	2.8	91.11
SP 701203H06	4	2469	10.68	11.54	102	2.9	91.53
SP 701206H06	5	2312	10.04	11.53	112	3.6	90.42
SP 701207H07	6	3104	12.60	12.29	103	2.5	91.46
SP 701201H03	7	1902	8.33	11.42	102	2.6	90.34
Acc. 2771	8	2059	10.07	10.22	111	6.5	88.47
Acc. 2168	9	2678	10.84	12.30	103	3.9	90.00
A71-5	10	3198	12.42	12.89	115	3.7	91.90
General mean		2433.56	10.46	11.56	106.7	3.67	90.54
CV (%)		14.0	11.7	5.0	8.3	17.8	2.2
LSD (.05)		341.37	1.22	.58	8.8	.65	1.96

<sup>1/</sup> Basis of leaf spot grades: 0 = healthy; 10 = complete defoliation.

Conducted by: Garry Smith, Earl Ruppel and Luther Lawson

Dates of Planting and Harvest: May 14, 1971; October 1, 1971.

Experimental Design (Including No. of Reps): Randomized Block; 8 replications; plots 2 rows x 20 feet; rows 22-inches apart.

Determination of Beet Yield and Sucrose Percentage: All beets were harvested in a competitive stand area (36 ft. of row) 18 ft. of each of two rows. Each sample was then topped, weighed, and analyzed for sugar.

Leaf Spot Exposure: Severe (artificially intensified).

Curly Top Exposure: Negligible.

Other Diseases and Pests: Negligible.

Reliability of Test and Remarks: Very satisfactory.

Table 9. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Plant Industry Station, Beltsville, Maryland

Seed no. or variety	Entry no.	Acre yield		Sucrose	Plants per 100'	Leaf spot <sup>1/</sup>
		Gross sucrose	Beets			
		Lbs.	Tons	%	No.	
Acc. 2707	1	6278	27.73	11.32	146	4.7
SP 691202H02	2	7250	30.93	11.72	132	3.7
SP 701203H02	3	8342	36.49	11.43	192	3.7
SP 701203H06	4	7269	32.98	11.02	164	3.8
SP 701206H06	5	6726	30.94	10.87	160	3.3
SP 701207H07	6	5194	24.34	10.67	103	2.8
SP 701201H03	7	9055	35.79	12.65	195	3.0
Acc. 2771	8	4391	23.94	9.17	145	5.0
(68519-01 x 67550-0)	9	7716	30.45	12.67	123	2.8
x 6822-0 (B)						
General mean		6913	30.40	11.28	151	3.6
CV (%)		14.1	14.1	4.0	12.5	11.2
LSD (.05)		2008	8.86	0.95	6.0	.84

<sup>1/</sup> Basis of leaf spot grades: 0 = healthy; 10 = complete defoliation.

Conducted by: Gerald E. Coe.

Dates of Planting and Harvest: April 27, 1971; October 7, 1971.

Experimental Design (Including No. of Reps): Randomized block; 3 replications; plots 4 rows x 20'; rows 24" apart.

Determination of Beet Yield and Sucrose Percentage: All beets in each of center 2 rows of each plot were topped approximately 1/2 inch below the apical meristem and weighed. The first 10 roots in each of these rows were washed and analyzed for sucrose percentage.

Leaf Spot Exposure: Moderately severe (artificially inoculated).

Curly Top Exposure: None.

Other Diseases and Pests: Crown Rhizoctonia - mild infestation and spotty; light infestation of mild beet yellows.

Reliability of Test and Remarks: Satisfactory. Rhizoctonia made LSD's rather large.

Table 10. Cooperative agronomic test of LSR-CTR varieties, 1971  
Location: Treshler Lease - Willcox, Arizona

Seed number or variety	Entry no.	Acre yield		Sucrose	Leaf spot	Brei Nitrate
		Gross sucrose	Beets			
		Lbs.	Tons	%		
Acc. 2707	1	7000	25.5	13.7	4.3	1.2
SP 691202H02	2	5900	21.7	13.6	4.3	1.1
SP 701203H02	3	7000	25.8	13.6	4.2	1.3
SP 701203H06	4	6860	26.5	12.9	4.5	1.1
SP 701206H06	5	6640	25.1	13.2	4.0	1.0
SP 701207H07	6	6040	20.7	14.6	3.2	1.0
SP 701201H03	7	6780	23.7	14.2	3.2	1.0
Acc. 2771	8	6460	26.3	12.3	6.5	2.3
S-701H	9	6780	26.6	12.8	4.7	1.8
S-501H	10	5180	19.8	13.1	4.7	1.3
S-301H8	11	5220	21.8	12.0	7.0	2.3
US H9B1	12	6300	25.2	12.5	5.7	1.4
General mean		6340	24.1	13.2	4.7	1.4
CV (%)		5.82	5.42	1.71	---	---
LSD (.05)		1064	3.7	0.6	---	---

<sup>1/</sup> Basis of leaf spot grades: 0 = no leaf spot; 10 = complete defoliation.

<sup>2/</sup> Basis for brei nitrate grades: 1 = no blue color; 4 = rapid dark blue color.

Conducted by: Spreckels Sugar Division of Amstar Corp. on Treshler Lease.

Dates of Planting & Harvest: March 12, 1971 and October 6, 1971.

Experimental Design (including no. of reps): Randomized complete block; 6 reps; Plot size - one bed x 50 ft. two rows 14" apart on each bed. Bed spacing was 40".

Determination of Beet Yield & Sucrose Percentage: Beet yields from whole plot weights. Two random sugar samples of 20-25 lbs. each per plot.

Leaf Spot Exposure: Severe.

Curly Top Exposure: Very slight.

Other Diseases & Pests: Very slight summer foliage damage by worms and slight Rhizoctonia infection, but too little to evaluate.

Reliability of Test & Remarks: Excellent reliability. 120 lbs. nitrogen applied by a preplant of 16-20-0 (30 lbs. N) and a sidedress of urea (90 lbs. N).

Table 11. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Hereford, Texas

Seed no. or variety	Entry no.	Acre yield		Sucrose	Plants per 100'	Leaf spot <sup>1/</sup>
		Gross sucrose	Beets			
		Lbs.	Tons	%	No.	
Acc. 2707	1	6847	34.2	10.02	151	3.0
SP 691202H02	2	5905	28.5	10.37	141	3.0
SP 701203H02	3	6240	29.8	10.48	134	2.7
SP 701203H06	4	6318	29.3	10.81	144	3.3
SP 701206H06	5	6952	32.1	10.84	157	3.0
SP 701207H07	6	6031	28.7	10.50	139	2.7
SP 701201H03	7	5916	31.2	9.51	152	1.7
Acc. 2771	8	6321	33.6	9.37	160	4.0
Check #1	9	6171	30.2	10.19	138	4.3
Check #2	10	7496	36.4	10.29	152	4.3
General mean		6420	31.4	10.24	147	3.2
CV (%)		11	10.3	5.88		
LSD (.05)		639	3.0	.57		

<sup>1/</sup> Basis of leaf spot grades: Data taken from leaf spot nursery.

Conducted by: Holly Sugar Corporation.

Dates of Planting and Harvest: March 28, 1971; November 13, 1971.

Experimental Design (Including No. of Reps): Randomized Complete Block; 9 replications.

Determination of Beet Yield and Sucrose Percentage: 25 foot plot divided into two samples, weighed, tared, sucrose analysis in tare lab.

Leaf Spot Exposure: Mild.

Curly Top Exposure: Mild.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Average reliability.

Table 12. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Rocky Ford, Colorado.

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	4342	3857	14.31	15.17	748
SP 691202H02	2	3764	3300	12.57	14.99	823
SP 701203H02	3	3327	2848	11.74	14.19	955
SP 701203H06	4	3266	2813	11.59	14.10	927
SP 701206H06	5	3154	2740	11.22	14.08	876
SP 701207H07	6	3602	3180	11.79	15.29	779
SP 701201H03	7	3328	2917	11.16	14.94	817
Acc. 2771	8	3722	3198	13.55	13.70	955
ACS Standard ck.	9	4290	3796	14.60	14.67	774
ACS (1861x1261)msx						
FC 903	10	3463	2970	11.82	14.63	945
ACS Check "A"	11	3314	2912	11.14	14.87	812
ACS Check "B"	12	3829	3424	12.00	15.97	707
General mean		3617	3163	12.29	14.72	843
CV (%)		13.56	13.98	12.00	3.75	8.58
LSD (.05)		705	636	2.12	.79	104

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: April 28, 1971; October 2, 1971.

Experimental Design (Including No. of Reps): Randomized block, 12 entries, 4 replications. Plot size was 2 row plots, 35 feet long, 22 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Good.

Table 13. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Two Buttes, Colorado

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	7166	5652	27.22	13.16	1411
SP 691202H02	2	7756	6155	29.08	13.34	1382
SP 701203H02	3	7767	6146	29.03	13.39	1397
SP 701203H06	4	7773	6202	28.46	13.65	1355
SP 701206H06	5	7540	5967	28.33	13.30	1389
SP 701207H07	6	7140	5702	26.14	13.65	1342
SP 701201H03	7	7387	5829	28.04	13.16	1407
Acc. 2771	8	7197	5625	27.96	12.88	1454
ACS Standard ck.	9	7827	6084	29.50	13.28	1480
ACS(1861x1261)ms x10 FC 903		6197	4768	24.87	12.44	1544
ACS Check "A"	11	6958	5556	25.40	13.70	1346
ACS Check "B"	12	6991	5660	24.25	14.43	1270
General mean		7308	5779	27.36	13.36	1398
CV (%)		9.24	9.93	8.73	3.01	7.49
LSD (.05)		979	833	3.46	.58	152

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: April 14, 1971; October 7, 1971.

Experimental Design (Including No. of Reps): Randomized Block, 12 entries, 4 replications. Plot size: 2 row plots, 35 feet long, 24 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Good.

Table 14. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Ulysses, Kansas

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	6181	5160	24.75	12.49	1103
SP 691202H02	2	7265	6008	28.65	12.68	1152
SP 701203H02	3	7432	6070	29.94	12.40	1226
SP 701203H06	4	6935	5733	27.91	12.42	1153
SP 701206H06	5	6269	5258	25.34	12.40	1072
SP 701207H07	6	6461	5497	24.39	13.24	994
SP 701201H03	7	6643	5607	26.60	12.50	1040
Acc. 2771	8	6272	5109	26.60	11.77	1238
ACS Standard ck.	9	6805	5750	26.67	12.77	1037
ACS(1861x1261)ms x						
FC 903	10	6169	5103	25.71	11.99	1153
ACS Check "A"	11	5618	4624	22.53	12.47	1182
ACS Check "B"	12	5936	5125	21.15	14.04	895
General mean		6499	5420	25.85	12.60	1104
CV (%)		6.95	7.09	5.34	5.19	12.54
LSD (.05)		650	553	1.99	.94	199

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: April 29, 1971; October 1, 1971.

Experimental Design (Including No. of Reps): Randomized Block, 12 entries, 4 replications. Plot size: 2 row plots; 35 feet long; 22 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Excellent.

Table 15. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Garden City, Kansas

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	4912	4119	18.65	13.19	1084
SP 691202H02	2	4489	3770	16.62	13.52	1069
SP 701203H02	3	5254	4378	18.72	14.04	1112
SP 701203H06	4	4803	4018	17.17	13.96	1089
SP 701206H06	5	4926	4130	17.80	13.83	1074
SP 701207H07	6	5209	4422	18.25	14.33	991
SP 701201H03	7	4861	4116	18.52	13.11	1026
Acc. 2771	8	4773	3989	18.10	13.19	1100
ACS Standard ck.	9	5501	4647	20.70	13.28	1042
ACS(1861 x 1261)						
ms x FC 903	10	4098	3338	15.63	13.17	1226
ACS Check "A"	11	4528	3878	15.87	14.25	960
ACS Check "B"	12	5270	4544	17.35	15.20	919
General mean		4885	4112	17.78	13.76	1058
CV (%)		11.85	11.58	12.55	3.87	10.92
LSD (.05)		833	685	3.21	.77	166

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: May 5, 1971; October 11, 1971.

Experimental Design (Including No. of Reps): Randomized Block; 12 entries; 4 replications. Plot size: 2 row plots, 35 feet long, 24 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Good.

Table 16. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Mason City, Iowa

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	5452	4636	20.06	13.59	985
SP 691202H02	2	5061	4317	18.32	13.82	973
SP 701203H02	3	4730	4072	17.15	13.79	902
SP 701203H06	4	3948	4570	13.55	14.57	803
SP 701206H06	5	4506	3872	16.47	13.68	939
SP 701207H07	6	5374	4564	20.25	13.27	1010
SP 701201H03	7	4930	4254	17.76	13.88	902
Acc. 2771	8	5329	4482	20.37	13.08	1058
ACS Standard ck.	9	5318	4443	20.37	13.05	1090
ACS(1861x1261)ms x						
FC 903	10	4834	4009	18.05	13.39	1025
SP 671203H08	11	4675	4196	16.60	14.08	872
SP 691203H02	12	4358	3780	16.01	13.61	874
General mean		4960	4266	17.91	13.65	953
CV (%)		28.01	26.78	43.72	5.67	17.16
LSD (.05)		1551	1267	8.19	.90	190

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: May 12, 1971; September 29, 1971.

Experimental Design (Including No. of Reps): Randomized Block; 12 entries, 6 replications. Plot size: 2 row plots, 35 feet long, 22 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Questionable.

Table 17. Leaf spot and curly top resistance of some LSR-CTR, monogerm lines evaluated at Fort Collins, Colorado and Logan, Utah, 1971.

Seed no.	Description	Leaf spot <sup>1/</sup> grade	Curly top <sup>2/</sup> grade	
			G.H.	Field
SP 701201H0	SP 6322-0	2.5	7.26	8.0
SP 701201H03	FC(504 x 502/2) x SP 6322-0	2.6	6.40	7.5
SP 701203H04	SP 652016s1 x FC 903	3.2	3.65	5.0
SP 701203H05	(SP 632028s1 x SP 652016s1) x FC 903	4.0	4.15	5.0
SP 701206H05	(SP 632028s1 x SP 652016s1) x McF 413	3.9	3.89	6.0
SP 701207H02	FC 506 x FC 701/2	2.7	6.10	8.0
SP 701207H03	FC(504 x 502/2) x FC 701/2	3.1	5.95	8.0
SP 701208H03	FC(504 x 502/2) x FC 702/2	3.6	5.55	8.0
SP 701212H02	SP 652016s1 x SP 662119s1	3.0	4.16	4.5
SP 701212H03	SP 642027s1 x SP 662119s1	4.0	4.35	6.5
	US 41		4.30	6.1
	US 33			7.0

<sup>1/</sup> 0 = healthy; 10 = complete defoliation.

<sup>2/</sup> At Logan, 0 = healthy; 9 = dead.

Table 18. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: East Grand Forks, Minnesota

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	6747	5954	22.63	14.92	792
SP 691202H02	2	6604	5896	20.95	15.77	711
SP 701203H02	3	7765	6820	25.42	15.27	812
SP 701203H06	4	7514	6691	23.97	15.70	730
SP 701206H06	5	6705	5932	21.98	15.25	767
SP 701207H07	6	6393	5735	20.35	15.72	682
SP 701201H03	7	7148	6304	23.55	15.17	789
Acc. 2771	8	7871	6862	26.88	14.63	861
ACS Standard ck.	9	7307	6362	25.19	14.57	854
ACS(1861 x 1261)						
ms x FC 903	10	6138	5423	19.87	15.44	778
ACS Hybrid "A"	11	6751	5999	21.85	15.54	735
ACS Hybrid "B"	12	7467	6756	22.82	16.37	631
General mean		7034	6228	22.95	15.36	762
CV (%)		11.22	11.31	11.13	3.08	10.42
LSD (.05)		913	815	2.96	.55	92

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: May 13, 1971; October 27, 1971.

Experimental Design (Including No. of Reps): Randomized Block; 12 entries; 6 replications. Plot size: 2 row plots, 35 feet long, 22 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Good.

Table 19. Cooperative Agronomic Test of LSR-CTR Varieties, 1971  
Location: Moorhead, Minnesota

Seed no. or variety	Entry no.	Gross Sugar Lbs./A	Gross Sugar -KSL*	Tons Beets /A	% Sugar	Impurity Index
Acc. 2707	1	6867	6206	22.78	15.12	638
SP 691202H02	2	6112	5572	19.38	15.79	588
SP 701203H02	3	6825	6156	21.99	15.54	651
SP 701203H06	4	5958	5410	19.24	15.48	614
SP 701206H06	5	6195	5613	20.55	15.08	627
SP 701207H07	6	5338	4842	17.08	15.63	619
SP 701201H03	7	6865	6240	22.64	15.16	606
Acc. 2771	8	6714	5990	23.34	14.38	719
ACS Standard ck.	9	6473	5877	21.32	15.18	613
ACS(1861 x 1261)						
ms x FC 903	10	5581	5002	18.78	14.85	694
SP 671203H08	11	6882	6272	22.22	15.50	588
SP 671203H02	12	6272	5739	20.30	15.43	566
General mean		6340	5743	20.80	15.26	627
CV (%)		6.79	6.59	7.04	2.88	11.89
LSD (.05)		498	438	1.69	.51	86

\* Known Sugar Loss

Conducted by: American Crystal Sugar Company.

Dates of Planting and Harvest: May 3, 1971; October 8, 1971.

Experimental Design (Including No. of Reps): Randomized Block, 12 entries, 6 replications. Plot size: 2 row plots, 35 feet long, 22 inch rows.

Leaf Spot Exposure: None.

Curly Top Exposure: None.

Other Diseases and Pests: None.

Reliability of Test and Remarks: Good.

## SUGARBEET RESEARCH

### 1971 Report

#### Section E

##### Michigan Agricultural Experiment Station, East Lansing, Michigan

Dr. G. J. Hogaboam, Research Agronomist  
Dr. C. L. Schneider, Plant Pathologist  
Dr. F. W. Snyder, Plant Physiologist  
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##### North Dakota Agricultural Experiment Station, Fargo, North Dakota

Dr. W. M. Bugbee, Plant Pathologist  
Dr. R. M. Cressman, Plant Physiologist

#### Cooperation:

Farmers and Manufacturers Beet Sugar Association  
American Crystal Sugar Company  
Holly Sugar Corporation  
Buckeye Sugars, Inc.  
Michigan Sugar Company  
Monitor Sugar Division  
Northern Ohio Sugar Company  
Michigan Agricultural Experiment Station  
Minnesota Agricultural Experiment Station  
North Dakota Agricultural Experiment Station  
Red River Valley Sugarbeet Growers Association, Inc.

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SUMMARY OF ACCOMPLISHMENTS, 1971

PLOT HARVESTING SYSTEM--With the help of Michigan State University, Agricultural Engineers, and our technicians we have developed a sugar-beet plot harvesting system. The objectives were to minimize time spent in the field and increase the precision of measurements. The field harvester lifts, tops, and cleans the dirt from the beets. The beets from a plot are caught in a plastic box where a plastic tag with two gummed labels with the plot identification is placed with the beets. The boxes are stacked on a platform on the harvester. At the end of the row the boxes are stacked on a wagon. The wagon is pulled into the barn and boxes are placed on a conveyor where the beets are counted and the number recorded on a 3x5 card. They are then conveyed over a printing scales where the weight and plot identification are placed on the 3x5 card. The other plot identification label is stuck to a juice container and placed in the box before it is conveyed to the saw. The beets are run through the saw and the pulp is collected and placed in a cloth. The juice container is placed under a funnel and the pulp is squeezed in the cloth over the funnel. 120 ml of juice is collected from each sample and immediately frozen to await sugar and purity analysis at the Sugar Laboratory. The remaining beets from the saw are conveyed up an elevator into a truck for delivery to the factory. G. J. Hogaboam, R. C. Zielke.

SUGARBEET STORAGE--Sugarbeet roots decline in processing quality after periods of time in storage piles. Investigations have been conducted to discern the reasons for the declining quality. Two of the more prominent factors involved are increases in reducing sugar and raffinose contents. It appears now that the increase in these two impurities in stored roots may be genetically controlled. Individual roots were analyzed for reducing sugars and raffinose after a prolonged storage period. The reducing sugar content ranged from values comparable to freshly harvested beets to thirty times greater. Raffinose contents of stored beets ranged up to twenty times those of fresh beets. The degree of heritability for low reducing sugar and raffinose content in stored beets is presently under investigation. R. C. Zielke.

APHANOMYCES COCHLIOIDES OOSPORES--Factors affecting oospore production in vitro were determined including type, concentration and pH of media, inhibitory effect of light and differences among fungus isolates. Longevity of oospores exceeded four years, but viability decreased notably after the second year. C. L. Schneider.

RHIZOCTONIA SOLANI STUDIES--In inoculation tests with Rhizoctonia-resistant cultivars no evidence of pathogenic races was found among R. solani isolates from Michigan and Ohio. Differences in Rhizoctonia-resistance between cultivars, apparent in the steckling stage, were not apparent in seedling stage with varying types, dosages, and methods of applying inoculum. It was shown that the practice of throwing soil in the crowns can greatly aggravate Rhizoctonia root rot damage in tolerant as well as in susceptible cultivars. C. L. Schneider.

SCREENING TESTS OF CHEMICALS AND BIOLOGICALS--DASS was the material that gave lasting protection against Aphanomyces cochlioides root rot in a field test of various soil treatments, and was the most effective seed treatment material as well. Chemical soil treatments including a soil fumigant, a nitrification stabilizer and PCNB fungicide did not effectively control Rhizoctonia root rot but control was obtained with the following, sprayed into the crowns: PCNB (2 and 4 a.i.a.) and chlorothalinol (1.5 lb). Among 23 chemical spray treatments tested for Cercospora leaf spot control, benomyl (3 oz a.i.a.) and thiophanate-methyl (5.6 and 8.4 oz) gave the most outstanding control even at 21-day schedules. C. L. Schneider.

AERIAL SPRAY TESTS TO CONTROL CERCOSPORA LEAF SPOT--Three trials were conducted in southern Michigan and northern Ohio. Satisfactory control was obtained with systemic (benomyl and thiabendazole) and with surface protecting (copper and tin compounds) fungicides with a maximum of two applications by fixed wing aircraft. C. L. Schneider (cooperative with H. S. Potter, P. Brimhall, and F. B. Russell).

EFFECT OF CROPPING SEQUENCE ON SUGARBEET DISEASES--Results of surveys made in 1969-1970-1971 of disease incidence in sugarbeet plantings on the Ferden Farm crop rotation plots show a definitely higher incidence of Aphanomyces seedling blight and root rot and of Rhizoctonia crown rot, in some years, in plots following alfalfa. C. L. Schneider (MSU Soils Dept., cooperator).

SCREENING BREEDING LINES FOR DISEASE RESISTANCE--Tests of 160 lines were conducted in the greenhouse for resistance to Aphanomyces cochlioides. Field tests were conducted in a nursery infested with given cultures of Rhizoctonia solani (198 lines tested) and in a nursery infested with Cercospora beticola dried leaf inoculum (221 lines). The tests permitted the screening of the more susceptible lines and the selection of the more resistant lines. C. L. Schneider, G. J. Hogaboam.

GERMINATION STUDIES--A study of the effect of maturity on water absorption by sugarbeet fruits revealed that immature fruits absorb more water than mature fruits. Immature fruits lost more weight by soaking in water and less by processing than mature fruits. It is more difficult to select cultivars for the best germination characters at maturity than at some stage of immaturity. Cultivars may differ significantly in their germination response to different pre-germination treatments such as soaking and processing and differences are accentuated when fruits are immature. Cultivars may differ significantly in fruit moisture content at specific times after first bloom. Generally those with the lowest percentage moisture also germinate better. The gravel emergence test was found to give low percentages of emergence for certain seedlots which are sensitive to an excess of water and thus did not always correlate with field emergence. Seedlots of the same cultivar may reveal remarkable differences in sensitivity to excess water and the quantity of water needed to be excessive is remarkably small. F. W. Snyder.

LEAF-AREA ACCRETION STUDIES--A study of the effect of a series of temperatures on leaf-area accretion showed that the lower the temperature, the less rapidly leaf area accretes. Cultivars which differed in yield in the field also differed in leaf area and root weight after about 30 days in the growth chamber. There is evidence that a cultivar that out yields another at the end of a growing season grows somewhat faster over the whole season and this increase in rate has been detected in a 30-day growth chamber experiment. The relation between fruit and seed sizes to subsequent cotyledon and leaf area has been examined for a few cultivars. Large fruit and seed size did not necessarily produce large cotyledons or leaf area 15 days after emergence. F. W. Snyder.

COMPARATIVE PHYSIOLOGICAL STUDIES--The physiological age of the leaf was found to markedly affect the  $\text{CO}_2$  compensation point in sugarbeet, soybean, and spinach, but is less marked in maize. Maize seedlings were found to have the  $\text{C}_4$ -dicarboxylic acid cycle of photosynthesis as early as 4 days after emergence. There is an indication that efficiency of  $\text{C}_4$  plants involves more than just this pathway of photosynthesis. F. W. Snyder, N. E. Tolbert, M. J. Abbate.

BREEDING STUDIES AT BELTSVILLE--Tests made in 1971 confirmed earlier indications that a new plateau in black root resistance has been reached in the multigerm pollinator line SP6934-0. Goals for ultimate levels of black root resistance have consequently been adjusted upward. Improvement in leaf spot resistance has slowed because of the high degree of resistance already attained. Only negligible losses occur to resistant breeding lines currently available to breeders, but the present commercial varieties lack this high level of resistance. The monogerm male sterile line, SP69550-01 has commercial potential but appears to be a poor seed producer. Breeding work is underway to develop globe-shaped sugarbeets capable of producing high yields with close plant spacing. Leaf spot resistance is being introduced through backcrossing. Improvements are also being made in sucrose percentage and root shape. Some progress has been made in discovering a culture media suitable for the growth of beet root tips. As yet, we have been unable to grow haploid plants from anthers on any of these media. G. E. Coe.

PHYSIOLOGICAL STUDIES AT FARGO--Measurements were made biweekly on root yield, top fresh and dry weights, and sucrose content of 14 varieties and lines of sugarbeets which included 2 lines of fodder beets and a "high sucrose" line. Root yield increased rapidly during August but leveled off in September. Top fresh weight increased rapidly during July, reached a peak in late August and declined during September. Sucrose concentration increased steadily from early July until harvest. Gross sucrose increased nearly linearly from late July to mid-September. Compared to the commercial beets, the fodder beets accumulated sugar much more slowly and maintained a lower top to root ratio, and the high sucrose beets had a higher rate of sucrose accumulation in September and developed a higher top to root ratio during August and September.

Sucrose distribution in beets was examined by histological and histochemical methods. In young beets sucrose accumulated gradually in all tissues. In old beets, sucrose concentrations were higher in the tissues of the vascular rings than in the interzonal parenchyma. In large beets with broad rings the differential between the sucrose concentration in the ring and the center of the interzone could be quite large. It appears that when beets accumulate less sugar because of greater growth, the interzonal tissue lags far behind the ring tissue in sugar concentration. The differences in sucrose concentrations between the two types of tissues also becomes a factor to consider when removing a brei sample from a beet; these differences appear to be more important than differences among locations in the beet. R. M. Cressman

STORAGE ROT STUDIES AT FARGO--The greatest loss of sucrose due to disease in the Red River Valley results from storage rot. Phoma betae is important because of its prevalence in stored beets and its ability to decay roots faster than other pathogens at low temperatures.

Optimum conditions for polygalacturonase production in culture by Phoma betae was:  $(\text{NH}_4)_2\text{SO}_4$  as the nitrogen source (6 organic and inorganic sources were tested); incubation temperature of 20C, although 15C was optimum for mycelial growth; and thiamine at 100 ug/L. Exo-polygalacturonase and endo-polygalacturonate trans-eliminase (endo-PGTE) were the pectolytic enzymes produced in culture and in diseased sugarbeet roots. It was concluded that endo-PGTE is more important because the pH of root tissue favors its activity and it is found in the advancing margins of decayed tissue.

Comparisons of the sugar contents of individual roots that have been inoculated with P. betae show inconsistent correlations with sucrose per cent and resistance; rather, cell walls appear to regulate pectolytic enzyme production and pathogenesis.

The world collection of Beta sp. was evaluated for resistance to P. betae. Of the 1,099 roots examined, 56 sugar types appeared resistant. Progeny of these selections will be tested again. W. M. Bugbee.

## Evaluation of Sugarbeet Hybrids

Prepared by G. J. Hogaboam and R. C. Zielke

The cooperative evaluation program ~~was~~ continued in 1971 with the Farmers and Manufacturers Beet Sugar Association and its member companies ~~as~~ well ~~as~~ with the Great Western Sugar Company and the American Crystal Sugar Company.

In the 6x6 Latin Square Tests, all individual experimental data were analyzed in indicated units and then the performance and LSD values were calculated ~~as~~ percent of the general mean. The analysis by area had the "location" effects removed by compositing the data ~~as~~ percent of the general ~~mean~~. Composite tests ~~were~~ made for the tests in the Ohio area, for tests in Michigan, and then all tests combined. The three Area Evaluation Tests are reported separately according to the ~~area~~ in which they ~~were~~ located.

Some of the characters (items) for which ~~we~~ analyzed data such as recoverable white sugar per acre, molasses sugar per ton of roots, etc., were calculated with formulas derived by M. G. Frakes, Director of Research, Michigan Sugar Company. The methods and techniques for such are outlined on page E2, 1970 Sugarbeet Research Report.

One commercial hybrid for the 1971 6x6 Latin Square is entry number 3, UI(11863x12161)xSP6322-0. This variety is very similar in breeding background to SL(129x133)xSP6322-0 which is US H20. The other commercial entry is number 1, UI(100363x2161)xSP6322-0.

The performance of entry 4 for high quality should be noted since it has exceeded all entries, ~~on~~ the average, in this respect for two years. ~~As~~ in past years, entries 1, 2 and 3 continue to outperform the other candidates in the testing program for recoverable white sugar per acre. Entry 4, however, is quite consistent in sugar per acre at all locations and is not significantly below the commercial check variety, entry 3.

In the Area Evaluation Tests, entries 2 and 15 have essentially the ~~same~~ genetic background ~~as~~ do entries 3 and 16. Entries 15 and 16 are the commercial hybrids presently in use. These four hybrids plus others involving the male steriles SP67557-1 and SP67550 (SP69550) exceed most other crosses at the 3 locations for recoverable white sugar per acre.

1971, 6x6 LSQ tests, Data as % of Performance of General Mean (G.M.)

Item	Loca- tion Code**	Variety Code@						LSD 5 % on%	Actual G.M.	C.V.%
		1	2	3	4	5	6			
Re- cover- able white sugar per acre	11*	98.2	109.3	99.8	95.8	104.8	92.1	9.0	6212 lbs	7.50
	12*	107.7	110.8	99.1	101.0	92.6	88.7	10.9	6139 lbs	9.04
	13	107.5	105.9	102.6	99.9	91.4	92.8	9.8	9342 lbs	8.11
	Ohio Avg*	107.5	108.7	101.5	98.9	96.3	91.2	8.4	100 %	4.61
	14	102.6	105.8	98.8	99.5	96.4	97.0	6.3	6636 lbs	5.20
	15	104.7	103.2	99.8	95.2	93.6	103.5	NS	5129 lbs	11.26
	Mich Avg	103.7	104.5	99.3	97.4	95.0	100.3	NS	100 %	2.84
	Grand Avg*	104.9	107.0	100.9	98.3	95.8	94.8	5.8	100 %	4.36
	Roots- Tons/ Acre	101.9	108.2	104.0	93.5	101.4	91.0	8.8	23.5 tons	7.32
	12*	110.7	110.4	103.7	95.2	90.4	89.5	8.1	32.3 tons	6.70
Re- cover- able white sugar per ton of roots	13	112.3	107.1	101.7	94.1	92.0	92.8	5.6	35.1 tons	4.62
	Ohio Avg*	112.3	108.6	104.4	94.3	94.6	91.1	7.0	100 %	3.86
	14	104.6	105.7	101.3	96.7	96.3	95.4	4.4	25.7 tons	3.62
	15	104.4	103.7	104.0	94.0	93.8	100.1	NS	18.1 tons	9.99
	Mich Avg	104.5	104.7	102.7	95.4	95.1	97.8	5.6	100 %	2.17
	Grand Avg*	107.1	107.0	103.9	94.7	94.8	93.8	4.8	100 %	3.63
	Re- cover- able white sugar per ton of roots	96.4	101.0	96.0	102.1	103.2	101.2	3.1	264.5 lbs	2.55
	12*	97.0	100.3	95.5	105.7	102.3	99.1	5.6	190.3 lbs	4.67
	13	95.7	98.8	100.6	106.0	99.2	99.8	5.0	266.9 lbs	4.10
	Ohio Avg*	95.7	100.0	97.1	104.6	101.6	100.0	3.7	100 %	1.99
	14	98.1	100.1	97.5	102.9	99.8	101.6	3.5	258.6 lbs	2.88
	15	100.4	99.2	96.0	101.6	100.0	103.0	3.8	282.6 lbs	3.13
	Mich Avg	99.3	99.7	96.8	102.3	99.9	102.3	2.9	100 %	1.10
	Grand Avg*	98.1	99.9	97.0	103.7	100.9	100.9	2.6	100 %	1.90

\*\*, @, \*, see page E10.

1971, 6x6 LSQ tests, Data as % of Performance of General Mean (G.M.)

Item	Loca- tion Code**	Variety Code <sup>@</sup>						LSD 5 % on % G.M.	Actual G.M.	C.V.%
		1	2	3	4	5	6			
% Su- crose	11*	97.6	101.0	97.3	100.5	102.0	101.6	2.7	16.00 %	2.21
	12*	98.2	99.3	97.1	103.7	101.8	99.9	NS	12.44 %	3.61
	13	96.5	98.3	100.4	104.7	99.8	100.4	3.8	16.21 %	3.14
	Ohio Avg*	96.5	99.5	98.1	103.0	101.2	100.6	3.0	100 %	1.62
	14	98.6	99.7	98.3	102.0	99.5	101.8	2.7	16.17 %	2.20
	15	100.1	99.3	97.1	101.6	99.6	102.2	3.0	16.93 %	2.51
	Mich Avg	99.4	99.5	97.7	101.8	99.6	102.0	1.7	100 %	0.65
	Grand Avg*	98.4	99.5	98.0	102.5	100.5	101.2	2.0	100 %	1.42
% CJ purity	11*	99.4	100.0	99.3	100.9	100.6	99.7	NS	94.54 %	1.01
	12*	99.5	100.6	99.2	100.9	100.2	99.5	0.9	91.34 %	0.72
	13	99.6	100.3	100.1	100.6	99.7	99.7	0.7	94.30 %	0.54
	Ohio Avg*	99.6	100.3	99.5	100.8	100.2	99.6	0.7	100 %	0.34
	14	99.7	100.3	99.6	100.4	100.1	99.8	NS	92.83 %	0.52
	15	100.1	99.9	99.4	100.0	100.2	100.4	0.6	94.94 %	0.48
	Mich Avg	99.9	100.1	99.5	100.2	100.2	100.1	NS	100 %	0.30
	Grand Avg*	99.8	100.2	99.5	100.6	100.2	99.8	0.5	100 %	0.36
Molas- s/s sugar /ton of roots	11*	107.5	100.8	108.1	85.5	91.6	106.5	11.0	28.3 lbs	9.15
	12*	103.7	93.1	105.3	93.8	99.4	104.7	8.4	34.2 lbs	6.95
	13	101.9	93.2	98.6	95.8	104.4	106.2	7.6	29.8 lbs	6.28
	Ohio Avg*	101.9	95.7	104.6	91.7	98.5	105.8	9.1	100 %	4.98
	14	102.0	96.2	103.7	96.6	97.5	104.0	NS	37.4 lbs	6.03
	15	97.6	100.4	107.7	102.5	95.7	96.1	NS	27.8 lbs	7.41
	Mich Avg	99.8	98.3	105.7	99.6	96.6	100.1	NS	100 %	3.92
	Grand Avg*	100.5	96.7	104.9	94.8	97.7	103.5	6.5	100 %	4.89

\*\*, @, \*, see page E10.

1971, 6x6 LSQ tests, Data as % of Performance of General Mean (G.M.)

Item	Loca- tion Code**	Variety Code <sup>@</sup>						LSD 5 % on % G.M.	Actual G.M.	C.V.%
		1	2	3	4	5	6			
Non- re- cover- able sugar /ton of roots	11*	98.8	100.5	98.6	100.3	101.0	100.8	1.4	27.1 lbs	1.12
	12*	99.1	99.7	99.1	101.6	100.8	100.0	1.9	24.1 lbs	1.56
	13	98.2	99.2	100.2	102.4	99.8	100.2	2.0	27.3 lbs	1.62
	Ohio									
	Avg*	98.2	99.8	99.2	101.4	100.5	100.3	1.5	100 %	0.78
	14	99.3	99.9	99.1	101.0	99.7	101.0	1.4	27.3 lbs	1.16
	15	100.1	99.7	98.5	100.8	99.7	101.2	1.6	27.9 lbs	1.32
	Mich									
	Avg	99.7	99.8	98.8	100.9	99.7	101.1	0.9	100 %	0.33
	Grand Avg*	99.2	99.8	99.1	101.2	100.2	100.6	1.0	100 %	0.71
% of gross as re- cover- able white sugar	11*	98.8	100.1	98.7	101.6	101.2	99.6	1.2	82.6 %	0.99
	12*	98.9	101.1	98.3	102.0	100.6	99.1	1.8	76.4 %	1.53
	13	99.2	100.5	100.2	101.2	99.5	99.4	1.3	82.3 %	1.10
	Ohio									
	Avg*	99.2	100.6	99.0	101.6	100.4	99.4	1.3	100 %	0.67
	14	99.5	100.5	99.1	100.9	100.2	99.8	NS	79.9 %	1.00
	15	100.3	99.8	98.8	100.0	100.4	100.7	1.1	83.4 %	0.90
	Mich									
	Avg	99.9	100.2	99.0	100.5	100.3	100.3	NS	100 %	0.54
	Grand Avg*	99.7	100.4	99.0	101.1	100.4	99.7	1.0	100 %	0.70
Beets per 100' of row	11*	96.6	101.7	100.0	100.0	106.9	94.8	NS	96.7 beets	6.54
	12*	101.4	101.4	101.4	103.2	99.7	92.8	NS	96.9 beets	6.20
	13	106.7	105.1	100.3	98.7	98.7	90.6	8.1	103.1 beets	6.71
	Ohio									
	Avg*	106.7	102.7	99.9	100.6	101.8	92.7	NS	100 %	3.47
	14	104.6	101.5	90.8	103.1	98.5	101.5	7.2	108.3 beets	5.96
	15	106.1	94.5	98.4	96.5	98.4	106.1	NS	86.4 beets	13.08
	Mich									
	Avg	105.4	98.0	94.6	99.8	98.5	103.8	NS	100 %	4.17
	Grand Avg*	105.8	100.8	98.4	100.3	100.4	97.2	NS	100 %	4.77

\*\*, @, \*, see page E10.

### Notes on the 6x6 Latin Square Tests

- \* Entry 1 at location 11 and location 12 is the same variety as entry 3. The Ohio average for entry 3 is thus obtained from 5 occurrences while the entry 1 data comes only from its occurrence at location 13. The Grand average for entry 3 comes from 7 occurrences while the Grand average for entry 1 is taken from its 3 occurrences. For the above reason, comparisons between entries 1 and 3 with the LSD values given are valid only in Michigan.

#### \*\* Location Code

- 11 - Russell Bros., Belmore, Ohio
- 12 - James Schroeder, Ottawa, Ohio
- 13 - Ralph Watson, Old Fort, Ohio
- 14 - Howard Hayward, Bay City, Michigan
- 15 - Walter Frahm, Frankenmuth, Michigan

#### @ Variety Code

##### Entry No.

1*	UI(100363 x 2161)	x SP6322-0
2	UI(100363 x 2161)	x SP6528-01
3	UI(11863 x 12161)	x SP6322-0
4	SP67550-02	x SP6822-0(P)
5	FC506	x SP6322-0
6	SP(6721-01 x 67555-0)	x SP6822-0(P)

### Notes for Area Evaluation Tests

Experimental Design: Randomized Complete Blocks

Replications: Russell Bros. and Schindler, 6 reps.; Hetzner, 5 reps.

Size of Plots: 2 row x 30 feet harvested for weight.

Sample for sucrose determinations: 5 consecutive beets from middle of each row combined into 1 sample.

1971 AREA EVALUATION TESTS

Russell Bros. Farm, Belmore, Ohio

CMS	HYBRID	"0"	Pollen	1	2	3	4	5	6	7	
				Performance in % of General Mean*							
UI100363	SP6423-0	SP6822-0(P)	116.5	112.2	104.1	102.6	100.8	89.4	101.6	116	
UI100363	SL133	" (P)	116.1	117.8	98.7	99.4	99.7	104.3	99.4	110	
UI1861	SL133	" (P)	118.8	115.5	102.9	102.9	100.0	103.7	100.0	110	
SP67557-1		SP6322-0	112.5	112.6	100.1	99.5	100.3	95.0	100.6	110	
SP67561-1		SP6322-0	88.2	87.2	101.3	101.3	100.0	102.0	100.0	88	
SP67505-01	SP67555-0	SP6822-0(P)	95.7	96.8	98.8	99.4	100.0	104.4	99.4	99	
SP67547-01	"	" (P)	84.9	89.3	95.4	97.2	99.1	110.5	98.2	90	
SP67519-01	"	" (P)	86.0	85.7	100.1	100.1	100.0	99.8	100.1	88	
"	SP67550-0	SP6822-0(B)	73.4	73.2	100.7	101.1	99.8	104.8	99.7	88	
SP68535-01	"	" (B)	91.5	92.6	99.2	99.4	99.9	101.4	99.7	92	
SP68608-1	"	SP6822-0(B)	91.3	99.3	91.5	94.2	98.6	113.3	97.1	92	
SP67550-02		SP6822-0(P)	97.1	95.6	101.5	100.1	100.8	88.8	101.4	105	
SP67550-01		SP6822-0(NB)	109.4	105.4	103.8	102.7	100.6	94.7	101.1	110	
SP69550-01		SP6322-0	106.4	104.3	102.2	101.6	100.3	98.0	100.6	99	
UI100363	UI2161	"	116.7	116.9	100.0	99.5	100.3	95.9	100.5	101	
UI1861	"	"	95.3	95.6	99.6	99.1	100.4	93.9	100.6	101	
General Mean (Actual)			5992	23.78	251.5	15.48	93.70	31.3	81.2	76	
5% LSD (for above data units)			12.9	11.6	4.9	3.7	0.8	10.0	1.6	12.7	
Coefficient of Variation (%)			11.2	10.1	4.3	3.2	0.7	8.7	1.4	11.0	

Schindler Farm, Kawkawlin, Michigan

UI100363	SP6423-0	SP6822-0(P)	104.1	102.6	101.7	100.2	100.8	89.3	101.4	104	
UI100363	SL133	" (P)	106.4	107.8	98.7	98.6	100.1	96.7	100.2	106	
UI1861	SL133	" (P)	97.5	102.2	95.7	96.5	99.7	100.6	99.2	106	
SP67557-1		SP6322-0	107.0	101.4	105.4	103.2	101.1	88.6	102.1	99	
SP67561-1		SP6322-0	95.8	91.9	104.1	103.6	100.2	101.2	100.6	101	
SP67505-01	SP67555-0	SP6822-0(P)	95.9	96.8	99.1	99.7	99.7	103.4	99.5	95	
SP67547-01	"	" (P)	81.1	82.8	97.6	97.6	100.1	96.5	100.3	97	
SP67519-01	"	" (P)	87.8	90.6	97.0	98.3	99.3	107.3	98.7	93	
"	SP67550-0	SP6822-0(B)	104.7	100.3	104.7	104.3	100.1	103.8	100.3	97	
SP68535-01	"	" (B)	96.3	98.1	97.9	98.8	99.6	105.0	99.1	92	
SP68608-1		SP6822-0(B)	98.6	102.2	96.8	98.5	99.1	111.1	98.2	103	
SP67550-02		SP6822-0(P)	104.8	102.7	101.5	101.3	100.1	100.2	100.2	103	
SP67550-01		SP6822-0(NB)	108.2	106.7	102.1	101.8	100.1	100.2	100.3	103	
SP69550-01		SP6322-0	111.1	107.4	103.8	103.4	100.1	102.5	100.3	103	
UI100363	UI2161	"	102.4	103.5	98.7	99.0	99.9	100.8	99.7	103	
UI1861	"	"	98.3	103.2	95.3	95.3	100.2	92.8	100.1	95	
General Mean (Actual)			7021	29.97	233.7	14.52	93.36	30.8	80.4	91	
5% LSD (for above data units)			NS	NS	6.0	5.1	0.94	NS	1.8	8.3	
Coefficient of Variation (%)			18.1	16.2	5.2	4.4	0.8	11.2	1.6	7.2	

Hetzner Farm, Saginaw, Michigan

UI100363	SP6423-0	SP6822-0(P)	101.8	103.9	98.3	97.9	100.3	94.4	100.5	103	
UI100363	SL133	" (P)	107.2	107.5	99.8	100.5	99.6	105.0	99.3	105	
UI1861	SL133	" (P)	110.5	108.9	102.0	101.0	100.5	95.0	101.0	107	
SP67557-1		SP6322-0	108.7	105.0	103.9	103.1	100.4	98.4	100.9	103	
SP67561-1		SP6322-0	88.1	86.8	101.5	102.1	99.6	106.9	99.3	96	
SP67505-01	SP67555-0	SP6822-0(P)	81.3	85.7	94.2	95.6	99.4	102.6	98.5	94	
SP67547-01	"	" (P)	99.1	96.6	103.5	104.0	99.6	108.6	99.5	96	
SP67519-01	"	" (P)	93.8	94.6	98.5	99.0	99.7	101.7	99.5	107	
"	SP67550-0	SP6822-0(B)	81.7	87.5	92.7	92.4	100.4	88.2	100.4	90	
SP68535-01	"	" (B)	98.5	99.1	99.6	100.6	99.4	107.6	98.9	96	
SP68608-1		SP6822-0(B)	98.8	102.7	96.5	97.6	99.4	104.1	98.8	94	
SP67550-02		SP6822-0(P)	105.7	100.9	105.4	103.9	100.6	96.0	101.4	103	
SP67550-01		SP6822-0(NB)	97.4	96.7	100.4	99.3	100.7	91.7	101.2	100	
SP69550-01		SP6322-0	109.8	104.7	105.3	104.6	100.2	101.7	100.7	98	
UI100363	UI2161	"	101.6	103.3	98.1	98.1	100.1	97.1	100.1	107	
UI1861	"	"	115.9	116.1	100.4	100.5	100.0	100.8	100.0	103	
General Mean (Actual)			7129	28.96	244.8	15.49	92.32	38.4	78.9	94	
5% LSD (for above data units)			NS	NS							
Coefficient of Variation (%)			18.2	15.1	6.3	5.7	1.0	13.8	2.0	8.9	

\*1 Recoverable white sugar (lbs/A)

2 Root yield (T/A)

3 Recoverable white sugar (lbs/T-roots)

4 % Sucrose

5 % Clear Juice Purity (CJP)

6 Molasses sugar (lbs/T-roots)

7 Recoverable white sugar as % of gross sugar

8 Beets per 100' of row

COOPERATOR: NORTHERN OHIO SUGAR COMPANY

BY: P. B. Brimhall, A. Erichsen, A. Suzuki,  
R. Oldemeyer, D. Sunderland, J. Widner

LOCATION: Cunningham Farm, Old Fort, Ohio

YEAR: 1971

CMS	HYBRID "0"	Pollen	1	2	3	4	5	6	7	8(a)	
			6 plot averages in % of SP5822-0								
SL129	SL133	SP6322-0	122.0 +	125.3 +	97.4	98.0	99.4	101.4	99.3	3.9	
SP65406-01	SP6442	02 clone	118.4	114.8	103.2	101.2	100.7	90.3	101.9	3.3	
EL35		SP6322-0	117.4	121.4 +	96.7	97.0	99.8	98.3	99.7	3.6	
SP6926-01		70P23	116.4	119.5 +	97.4	97.5	99.6	97.9	99.9	3.0	
SP68682-1		SP6322-0	115.6	115.6	99.9	99.6	100.6	97.4	100.4	2.2	
EL35		02 clone	114.4	116.4	98.3	100.1	98.8	109.9	98.2	4.1	
SP67557-1		SP6322-0	113.3	106.3	106.6	106.1 +	99.9	104.4	100.4	2.2	
SP68747-1		"	113.1	116.0	97.5	97.4	99.8	96.7	100.1	2.5	
SP68661-1		"	112.1	107.2	104.6	104.4	99.8	103.7	100.2	2.5	
SP6426-01		SP6822-0	111.7	113.2	98.7	97.0	100.6	87.2	101.7	3.3	
SP6426-01	SP67550-0	SP6322-0	110.6	103.7	106.6	104.9 +	100.6	95.9	101.6	2.6	
SP6926-01		70P21	110.1	113.9	96.6	96.5	100.0	95.3	100.1	3.3	
SP68625-1		SP6322-0	109.7	113.1	96.9	97.2	99.7	98.2	99.7	2.4	
SP68599-02	SP67550-0	"	109.1	104.6	104.3	104.4	99.8	105.4	99.9	1.7	
SP67561-1		"	108.9	99.7	109.3	108.2 +	100.1	103.1	101.0	2.0	
SP6926-01		"	108.9	113.1	96.2	96.4	99.8	97.0	99.8	3.0	
SP68641-1		"	108.4	112.3	96.6	95.4	100.5	87.9	101.3	2.5	
SP65599-01		SP6822-0	108.2	103.4	104.6	102.3	100.7	89.7	102.3	1.8	
SP67550-01		"	107.8	100.7	107.1	106.3 +	100.2	103.1	100.7	2.3	
SP68537-01	SP67550-0	SP6322-0	106.9	97.7	109.5	108.4 +	100.1	103.3	101.0	2.3	
SP69550-01		70P23	106.7	99.8	106.9	107.3 +	99.6	110.8	99.6	2.4	
SP67505-01	SP67555-0	SP6322-0	105.6	101.3	104.3	103.8	100.1	101.4	100.5	2.9	
SP68533-01	SP67550-0	SP6322-0	103.4	105.3	98.2	99.5	99.3	106.5	98.7	2.0	
SP6423-01	SP67550-0	"	103.3	100.6	102.7	102.8	99.7	103.8	99.9	3.3	
SP68608-1		"	102.4	97.7	104.8	102.2	100.6	88.0	102.5	2.5	
SP68744-1		"	102.4	108.1	94.7	96.9	98.9	108.3	97.8	3.3	
SP69550-01		"	101.8	92.3	110.4	106.6 +	100.8	86.5	103.5	1.8	
SP6721-01	SP67555-0	"	100.9	98.6	102.3	102.9	99.9	106.4	99.5	2.5	
SP68735-1		"	100.5	108.1	92.9	94.8 -	99.2	104.4	98.1	3.5	
SP68535-01	SP67550-0	"	100.0	93.8	106.6	103.3	100.7	84.8	103.3	1.8	
SP67550-02		SP6822-0	97.5	92.3	105.6	104.7	100.2	99.9	100.9	1.9	
SP68522-01	SP67550-0	"	91.6	91.3	100.4	101.7	99.3	109.1	98.8	2.6	
SP68555-01		"	90.3	90.9	99.4	99.1	100.1	97.5	100.3	2.3	
Mean for SP5822-0			5966	1bs	25.65T	232.6	1bs	14.0%	91.9%	41.5	83.0%
Test Mean			6410	1bs	27.16T	236.6	1bs	14.19%	91.8%	41.2	83.4%
LSD 5% pt. (% of SP5822-0)			20.06	18.18	-	4.77	NS	-	-	-	-
CV (%)			16.25	15.03	-	3.90	1.38	-	-	-	-

+ or - Statistically above or below SP5822-0 at 5% level of significance

\*1 Recoverable white sugar (lbs/A)

5 % Purity

2 Root yield (T/A)

6 Molasses sugar (lbs/T-roots)

3 Recoverable white sugar (lbs/T-roots)

7 % Extraction

4 % Sucrose

8 Leaf spot actual average rating

(a) 0 = no disease, 10 = completely defoliated

COOPERATOR: NORTHERN OHIO SUGAR COMPANY

BY: P. B. Brimhall, A. Erichsen, A. Suzuki,  
R. Oldemeyer, D. Sunderland, J. Widner

**LOCATION: Lindsey, Ohio**

YEAR: 1971

HYBRID		6 plot averages in % of SP5822-0 (a)				
CMS	"0"	Pollen	Gross	Root	%	Leaf
			Sugar	Yield	Sucrose	Spot
SL129	SL133	SP6322-0	130.6 +	129.7 +	100.6	3.4
SP68641-1		"	123.6 +	124.6 +	98.9	2.9
EL35		"	120.0 +	120.9 +	99.1	2.3
SP68747-1		"	117.4 +	117.4 +	99.9	2.3
SP67561-1		"	117.3 +	111.1	105.7 +	2.2
SP68533-01	SP67550-0	"	114.9	110.4	103.7	1.6
SP67557-1		"	114.2	109.5	104.1	2.1
SP68682-1		"	113.0	112.3	100.3	3.0
SP65406-01	SP6442	02 clone	110.4	107.0	102.9	4.3
SP6423-01	SP67550-0	SP6322-0	110.1	109.8	100.1	2.5
SP67550-02		SP6822-0	109.3	103.5	105.4 +	2.3
SP68735-1		SP6322-0	109.2	114.6 +	94.9 -	3.4
SP68608-1		"	108.7	110.3	98.3	2.0
SP67550-01		SP6822-0	108.6	105.2	103.1	1.6
SP6426-01		"	108.0	114.9 +	94.2 -	2.8
SP68599-02	SP67550-0	SP6322-0	107.9	103.2	104.4	1.4
SP67505-01	SP67555-0	"	107.1	107.7	99.1	2.2
SP6426-01	SP67550-0	"	106.6	103.7	102.2	2.8
SP65599-01		SP6822-0	106.4	103.0	102.9	1.7
SP6926-01		70P21	106.4	107.8	98.4	3.4
SP68625-1		SP6322-0	104.8	106.0	98.4	2.7
SP68661-1		"	104.8	105.8	98.9	2.4
SP68555-01		"	104.2	99.6	105.0	2.8
SP68744-1		"	104.0	104.0	99.9	3.7
SP69550-01		70P23	102.5	97.0	105.1	3.2
SP6926-01		SP6322-0	101.5	106.6	95.0	2.6
SP68522-01	SP67550-0	"	101.1	99.4	101.6	1.9
SP6721-01	SP67555-0	"	100.5	97.8	102.7	2.2
SP69550-01		"	99.7	97.9	101.0	1.6
SP68537-01	SP67550-0	"	99.6	98.0	101.4	2.7
SP68535-01	SP67550-0	"	98.8	102.3	96.6	1.7
EL35		02 clone	94.7	100.3	93.9 -	3.8
SP6926-01		70P23	93.3	100.4	92.3 -	2.8
Mean for SP5822-0			8120 lbs	28.55T	14.22%	2.5

+ or - Statistically above or below SP5822-0 at 5% level of significance  
(a) Actual average rating; 0 = no disease, 10 = completely defoliated

1971 - Mason City, Iowa Test of East Lansing 1970 USDA Hybrids

By American Crystal Sugar Company

Variety	Tons Per Acre			Percent Sugar			Gross Sugar/Acre		
	Mean	Rank	Pct.	Mean	Rank	Pct.	Mean	Rank	Pct.
SP 69550-01 x SP 6322-0	13.81	8	97.6	13.40	4	101.5	3702	6	98.9
SP 6926-01 x 70 P21	14.92	2	105.4	12.90	9	97.7	3846	2	102.9
SP 6926-01 x 70 P23	14.53	3	102.6	13.01	6	98.6	3783	4	101.2
SP 6926-01 x SP 6322-0	13.98	6	98.7	12.81	10	97.0	3581	9	95.8
SL (129 x 133) ms x SP 6322-0 (Standard Check)	13.98	5	98.7	12.99	8	98.4	3628	8	97.0
UI 11866 x UI 12166 x 70 P21	13.64	9	96.4	13.66	1	103.5	3731	5	99.8
UI 11866 x UI 12166 x 70 P23	14.00	4	98.9	13.11	5	99.3	3686	7	98.6
SP 68555-01 x SP 6322-0	13.12	10	92.7	13.01	7	98.6	3421	10	91.5
UI 100363 x UI 12163 x 70 P21	15.68	1	110.7	13.47	3	102.1	4223	1	112.9
UI 100363 x UI 12163 x 70 P23	13.92	7	98.3	13.66	2	103.5	3793	3	101.4
Overall Mean	14.16		13.20				3739		
LSD (.05)	2.45		.53				664		
F. Value	.72		2.97				.84		
C. V. %	11.94		2.79				12.23		

Variance Table

Source	D/F	Tons			Gross	
		Beets/Acre	Sugar		Sugar	
Replications	3	17.5754		.1027	1,300,453	
Varieties	9	2.0574		.4029	171,801	
Error	27	2.8567		.1356	209,242	
Total	39					

Design: Randomized Block, 10 entries, 4 replications.

Plot Size: 1 row plots, 35 feet long, 22 inch rows.

Planted: May 11, 1971

Harvested: September 28, 1971

## By American Crystal Sugar Company

- E15 -

Variety	Gross Sugar Lbs./A.	Gross Sugar - KSL*	Tons Beets /A.	% Sugar	Impurity Index
SL (129 x 133) ms x SP 6322-0	4276	3736	14.79	14.41	839
SP 67561-1 x SP 6322-0	3835	3419	13.14	14.70	729
SP 67550-01 x SP 66288-2L	3288	2902	12.02	13.60	775
SP 67557-1 x SP 6322-0	3980	3559	14.28	13.94	705
(SP 6423-01 x SL 133) x 02 Clone	3977	3542	13.73	14.46	736
(UI 100363 x SP 673465) x 02 Clone	3709	3221	13.17	14.09	787
SP 6423-01 x UI 4661 x 02 Clone	4172	3663	15.23	13.67	816
SP 6426-01 x SP 67555-0 x FC 701/2	3712	3257	13.26	14.10	812
(63-5HO x FC 502) x 5L-60L	3532	3111	12.27	14.17	768
(AI-1 x AI-2) ms x 5L-60L	4022	3550	14.18	14.21	776
63-(5HO x 6) x 5L-60L	3768	3232	13.27	14.05	919
63-6HO x 5L-60L	3684	3238	13.25	13.95	811
68-312 ms x 5L-60L	3662	3203	12.86	14.34	845
SP 67555-01 x 5L-60L	3555	3088	12.78	14.06	866
SL (129 x 133) ms x 66-405B	3876	3436	13.39	14.42	750
63-(5HO x 6) x 66-405B	3958	3503	14.24	13.94	773
Overall Mean	3813	3357	13.49	14.13	795
LSD (.05)	4.32	3.78	1.59	.65	1.23
F. Value	3.10	3.37	2.77	1.42	1.72
C. V. %	9.79	9.74	10.22	4.21	13.38
* - Known Sugar Loss					
Source	D/F	Gross Sugar	Gross Sugar - KSL	Tons Beets/A	% Sugar
Replications	5	2,518,892	1,884,456	31.8565	.6525
Varieties	15	380,607	316,440	4.5532	.5025
Error B	18	248,141	193,758	3.8580	-
Error E	56	122,682	93,907	1.6458	.3546
Total	94				10,478
Variance Table					

Design: 4 x 4 Triple Lattice, 16 entries, 6 replicates.  
 Plot Size: 2 row plots, 35 feet long, 22 in. rows  
 Planted: May 11, 1971  
 Harvested: September 28, 1971

1971 - First Retest of USDA & ACS Hybrids - Mason City, Iowa

By American Crystal Sugar Company

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beets /A	% Sugar	Impurity Index
SL (129 x 133) ms x SP 6322-0	4775	4201	16.99	11.06	802
SP 67533-1 x SP 6322-0	4496	3961	15.99	11.09	783
SP 67588-2 x SP 6322-0	4608	4133	16.06	11.37	682
(UI 1861 x SL 133) x 02 Clone	4100	3628	11.14	11.53	766
(UI 100363 x SL 133) x 02 Clone	4566	4020	16.02	11.27	796
(UI 1861 x SP 6423-0) x 02 Clone	4564	4035	15.53	11.71	776
(UI 100363 x SP 6423-0) x SP 6822-0	4847	4221	17.32	13.99	861
(UI 1861 x SL 133) x SP 6822-0	4376	3849	15.59	11.02	802
(UI 100363 x SL 133) x SP 6822-0	4843	4233	17.19	11.08	838
(UI 1861 x SP 6423-0) x SP 6822-0	4487	3915	15.81	11.22	844
(AI-2 x AI-2) ms x 74842	4373	3012	12.35	11.08	890
SP 6423-01 x 74832	4362	3798	15.27	11.31	861
(SL 129 x 63-6) x C-413	3813	3293	13.46	11.16	906
(63-8HO x FC 502) x C-413	3624	3170	13.13	13.78	834
63-(5HO x 6) x C-413	4090	3454	15.23	13.46	1033
63-5HO x C-713	3871	3327	13.93	13.87	942
Overall Mean	4306	3766	15.25	11.12	838
LSD (.05)	452	401	1.63	.69	114
F. Value	8.26	9.00	7.35	1.59	4.50
C. V. %	9.07	9.21	9.27	4.23	11.74

\* - Known Sugar Loss

Source	D/F	Gross Sugar	Gross Sugar - KSL	Tons Beets/A	% Sugar	Impurity Index
Replications	5	887,706	627,168	9.7786	.1241	4,424
Varieties	15	1,114,087	964,278	12.9740	.5167	39,104
Error B	18	267,831	199,748	3.4899	.5349	15,378
Error E	57	134,800	107,151	1.7660	.3241	8,688
Total	95					

Design: 4 x 4 Triple Lattice, 16 entries, 6 replications.

Plot Size: 2 row plots, 35 feet long, 22 inch rows.

Planted: May 12, 1971

Harvested: September 29, 1971

1971 - Second Retest of USDA Hybrids - Mason City, Iowa

By American Crystal Sugar Company

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beets /A.	% Sugar	Impurity Index
SL (129 x 133) ms x SP 6322-0	6082	5146	23.32	13.38	950
(UI 100363 x 2161) x 02 Clone	4730	4017	17.59	13.52	991
UI 1861 x SP 6528-01	4316	3737	16.12	13.40	892
SP 64502-01 x SP 6442-0 x 02 Clone	3903	3446	13.94	14.12	780
UI 1861 x 02 Clone	4119	4665	14.58	14.29	777
SL (129 x 133) x 02 Clone	4645	4088	16.21	14.37	790
UI 100363 x SP 6528-01	4368	3810	16.14	13.56	853
UI 12163 x SP 6322-0	4766	4054	17.42	13.73	976
SP 67550-02 x SP 6322-0	4522	3944	16.32	13.84	854
Overall Mean	4609	3990	16.84	13.80	874
LSD (.05)	1690	1537	7.04	.75	118
F. Value	1.10	1.03	1.20	2.12	4.14
C. V. %	31.43	29.14	35.84	4.63	11.57

\* = Known Sugar Loss

Source	D/F	Variance Table			
		Gross Sugar	Gross Sugar - KSL	Tons Beets /A	% Sugar
Replications	5	3,457,421	2,217,035	65.2874	1.1522
Varieties	8	2,302,603	1,387,914	46.6311	.8647
Error	40	2,098,676	1,351,720	36.4296	.4079
Total	53				10,218

Design: Randomized Block, 9 entries, 6 replications.

Plot Size: 2 row plots, 35 feet long, 22 inch rows.

Planted: May 11, 1971

Harvested: September 28, 1971

1971 Test of Dr. Coe's USDA mm Lines

Mason City, Iowa

By American Crystal Sugar Company

Variety	Tons Per Acre			Percent Sugar			Lbs. Sugar/Acre		
	Mean	Rank	Pct.	Mean	Rank	Pct.	Mean	Rank	Pct.
SL (129 x 133) x SP 6322-Q (Standard Check)	14.48	3	109.8	13.29	4	101.6	3843	3	111.7
SP 68820-4, 7, 19 MM, MS x SP 67527 mm (C Type)	11.11	12	84.5	13.45	1	102.8	2985	12	86.8
"	15.11	2	114.8	12.97	8	99.2	3927	1	114.1
"	11.90	11	90.3	13.35	2	102.0	3170	11	92.1
"	13.90	4	105.4	12.91	9	98.7	3569	4	103.7
"	12.13	10	92.1	13.27	5	101.5	3220	10	93.6
"	12.57	7	95.4	12.89	10	98.5	3229	8	93.8
"	13.44	5	102.0	13.21	6	101.0	3554	5	103.3
"	12.51	8	94.9	13.34	3	101.9	3325	7	96.9
"	12.39	9	94.0	13.30	7	99.4	3223	9	93.7
"	13.20	6	100.2	12.75	11	97.1	3367	6	97.9
"	15.37	1	116.6	12.57	12	96.1	3866	2	112.4
Overall Mean	13.18		13.08				3441		
LSD (.05)	2.95		4.6				754		
F. Value	1.66		2.99				1.39		
C. V. %	15.58		2.46				15.21		

Overall Mean  
LSD (.05)  
F. Value  
C. V. %

Variance Table

Source	D/F	Tons		Gross Sugar
		Beets/Acre	Sugar	
Replications	3	23.0054		1,299,439
Varieties	11	6.9826		380,712
Error	33	4.2153		274,877
Total	47			

Design: Randomized Block, 12 entries, 4 replications.  
Plot Size: 1 row plots, 35 feet long, 22 inch rows.  
Planted: May 11, 1971  
Harvested: September 28, 1971

## 1971 Test of Dr. Coe's 1970 USDA Hybrids

## Mason City, Iowa

## By American Crystal Sugar Company

Variety	Tons Per Acre			Percent Sugar			Gross Sugar/Acre		
	Mean	Rank	Pct.	Mean	Rank	Pct.	Mean	Rank	Pct.
SL (129 x 133) ms x SP 6322-0 (Standard Check)	13.10	10	100.6	13.46	5	102.0	3526	9	102.8
SP 68608-1 x SP 6822-0 (B)	11.22	4	109.2	13.52	3	102.5	3842	3	112.0
SP 68625-1 x "	11.59	3	112.0	13.07	13	99.1	3824	4	111.5
SP 68641-1 x "	13.79	7	105.8	12.93	16	98.1	3587	7	104.6
SP 68661-1 x "	12.50	15	95.9	13.12	12	99.5	3286	14	95.8
SP 68682-1 x "	13.52	8	103.8	12.71	20	96.4	3439	12	100.3
SP 68735-1 x "	16.14	1	123.9	12.50	21	94.8	4020	1	117.2
SP 68744-1 x "	12.84	13	98.6	12.81	17	97.1	3281	15	95.7
SP 68747-1 x "	15.66	2	120.3	12.80	18	97.0	4009	2	116.9
SP 68599-02 ms x	11.79	19	90.5	13.47	4	102.1	3182	18	92.8
SP 67550-01 x SP 6822-0 (Non-Bolting Selection)	12.98	11	99.6	13.45	6	102.0	3494	10	101.9
SL (129 x 133) ms x SP 6322-0 (Standard Check)	11.32	19	86.9	13.41	8	101.7	3041	19	88.7
SP 6423-01 x SP 67550-0 x SP 6822-0 (B)	11.19	20	85.9	13.42	7	101.8	3001	20	87.5
SP 6426-01 x "	12.88	12	98.9	12.79	19	96.9	3295	13	96.0
SP 68519-01 x "	9.21	21	70.7	13.07	14	99.1	2412	21	70.3
SP 68522-01 x "	12.24	16	93.9	13.39	9	101.5	3267	16	95.3
SP 68537-01 x "	11.90	17	91.4	13.66	2	103.6	3245	17	94.6
SP 67505-01 x SP 67555-0 x SP 6822-0 (B)	13.87	5	106.5	13.21	11	100.2	3605	6	105.1
SP 67519-01 x "	12.73	14	97.7	13.95	1	105.7	3554	8	103.6
SP 67547-01 x "	13.86	6	106.4	13.27	10	100.6	3677	5	107.2
SP 6721-01 x "	13.23	9	101.6	13.01	15	98.6	3448	11	100.5
Overall Mean	13.03		13.19				3430		
LSD (.05)	3.35		.65				860		
F. Value	1.70		2.44				1.47		
C. V. %	18.14		3.48				17.71		

Variance Table

Source	D/F	Tons Beets/Acre	Tons Sugar		Gross Sugar
			%	%	
Replications	3	14.3121	.0129	1.029,810	
Varieties	20	9.5024	.5134	544,646	
Error	57	5.5817	.2106	369,052	
Total	80				

Design: Randomized Block, 21 entries,

4 replications

Plot Size: 1 row plots, 35 feet long, 22 inch rows.

Planted: May 11, 1971

Harvested: September 28, 1971

1971 Test of Dr. Coe's USDA mm Lines - East Grand Forks, Minnesota

By American Crystal Sugar Company

Variety			Lbs. Sugar Per Acre	Tons Per Acre	% Sugar
SL (129 x 133) ms x SP 6322-0			5045	18.11	14.01
SP 68820-4, 7, 19 MM, MS x SP 67527	mm (O Type)		4054	14.48	14.04
" " x SP 68068	mm "		4711	18.39	12.86
" " x SP 68620A	mm "		4561	17.83	12.85
" " x SP 68641	mm "		4455	17.89	12.49
" " x SP 68661	mm "		4019	16.03	12.62
" " x SP 68682	mm "		4799	19.23	12.57
" " x SP 68689	mm "		4313	17.51	12.30
" " x SP 68730	mm "		3932	14.80	13.31
" " x SP 68735	mm "		4913	19.61	12.52
" " x SP 68745	mm "		4059	15.61	13.05
" " x SP 68756	mm "		4841	19.98	12.10
Overall Mean			4475	17.46	12.89
LSD (.05)			489	1.76	.80
F. Value			5.33	9.04	4.94
C. V. %			7.60	7.01	4.32

Variance Table

Source	D/F	Gross Sugar	Tons Beets/A	% Sugar
Replications	3	1,189,852	4.7872	20.5826
Varieties	11	617,502	13.5252	1.5345
Error	33	115,761	1.4962	.3104
Total	47			

Design: Randomized Block, 12 entries, 4 replications.

Plot Size: 1 row plots, 35 feet long, 22 inch rows.

Planted: May 13, 1971

Harvested: September 22, 1971

1971 Test of Dr. Coe's 1970 USDA Hybrids  
East Grand Forks, Minnesota

By American Crystal Sugar Company

Variety	Gross Sugar Lbs./A	Tons Beets /A	% Sugar
SL (129 x 133) ms x SP 6322-0	4934	19.34	12.81
SP 68608-1 x SP 6822-0 (B)	4751	20.50	11.89
SP 68625-1 x ■	4615	19.59	11.85
SP 68641-1 x ■	4476	19.48	11.47
SP 68661-1 x ■	3975	15.45	13.02
SP 68682-1 x ■	4849	18.99	12.76
SP 68735-1 x ■	4963	20.10	12.35
SP 68744-1 x ■	4394	18.04	12.26
SP 68747-1 x ■	4558	18.93	12.12
SP 68599-02 ms x ■	4604	17.18	13.36
SP 67550-01 x SP 6822-0 (Non-Bolting Selection)	4839	19.06	12.77
SL (129 x 133) ms x SP 6322-0	5034	20.11	12.62
SP 6423-01 x SP 67550-0 x SP 6822-0 (B)	4666	18.62	12.55
SP 6426-01 x " "	5279	19.55	13.54
SP 68519-01 x " "	3883	14.63	13.06
SP 68522-01 x " "	4628	17.33	13.46
SP 68537-01 x " ■	4350	16.35	13.30
SP 67505-01 x SP 67555-0 x SP 6822-0 (B)	4816	17.70	13.60
SP 67519-01 x " "	4435	16.31	13.56
SP 67547-01 x " "	4231	16.48	12.92
SP 6721-01 x " ■	4606	17.86	12.89
Overall Mean	4614	18.17	12.77
LSD (.05)	739	2.87	.91
F. Value	1.66	2.61	3.56
C. V. %	11.33	11.17	5.06

Variance Table

Source	D/F	Gross Sugar	Tons Beets/A	% Sugar
Replications	3	1,983,511	14.2240	35.3652
Varieties	20	454,493	10.7536	1.4859
Error	60	273,143	4.1172	.4178
Total	83			

Design: Randomized Block, 21 entries, 4 replications.

Plot Size: 1 row plots, 35 feet long, 22 inch rows.

Planted: May 14, 1971

Harvested: September 23, 1971

1971 Test of East Lansing USDA 1970 Hybrids, East Grand Forks

By American Crystal Sugar Company

Variety	Lbs. Sugar Per Acre	Tons Per Acre	% Sugar
SP 69550-01 x SP 6322-0	4702	17.55	13.44
SP 6926-01 x 70 P21	4715	18.58	12.72
SP 6926-01 x 70 P23	4713	19.70	12.00
SP 6926-01 x SP 6322-0	5162	20.63	12.52
SL (129 x 133) ms x SP 6322-0	5406	20.16	13.44
UI 11866 x UI 12166 x 70 P21	5354	20.15	13.34
UI 11866 x UI 12166 x 70 P23	4927	18.16	13.66
SP 68555-01 x SP 6322-0	4581	18.00	12.82
UI 100363 x UI 12163 x 70 P21	4950	18.59	13.44
UI 100363 x UI 12163 x 70 P23	5285	20.96	12.69
Overall Mean	4979	19.25	13.01
LSD (.05)	532	1.93	1.23
F. Value	2.74	3.30	1.59
C. V. %	7.37	6.92	6.49

Variance Table

Source	D/F	Gross Sugar	Tons Beets/A	% Sugar
Replications	3	193,197	12.3126	10.5241
Varieties	9	368,556	5.8594	1.1360
Error	27	134,573	1,7747	.7130
Total	39			

Design: Randomized Block, 10 entries, 4 replications.

Plot Size: 1 row plots, 25 feet long, 22 inch rows.

Planted: May 15, 1971

Harvested: September 24, 1971

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beet■ /A	% Sugar	Impurity Index
SL (129 x 133) ms x SP 6322-0	6606	5864	23.08	24.51	757
SP (67519-01 x 67555-0) x SP 6822-0	5327	4686	18.55	24.47	848
SP 67543-1 x SP 6322-0	5078	4436	17.66	24.65	865
(UI 12163 x SP 673465-0) x 02 Clone	5806	5086	20.88	24.03	823
(UI 100363 x SP 6423-0) x 02 Clone	5854	5236	20.40	24.26	722
(UI 1861 x SP 673465-0) x SP 6822-0	5658	4986	20.21	24.00	777
(UI 100363 x SP 673465-0) x SP 6822-0	5299	4647	18.72	24.11	853
(63-8HO x 63-6) x 54-604	5731	5051	19.06	24.81	759
(SL 129 x FC 504) x 54-604	6001	5386	19.84	25.06	699
63-5HO x 54-604	5523	4849	19.26	24.52	813
67-69HO x 54-604	5343	4738	18.23	24.96	738
SP 67519-01 x 54-604	5676	5031	19.03	24.77	758
SP 66550-01 x 54-604	5603	5048	18.85	24.71	719
68-314 ms x 74842	6588	5777	22.50	24.62	832
68-314 ms x 74832	6145	5336	21.82	24.25	889
68-314 ms x 74831	5949	5165	20.63	24.28	880
Overall Mean	5762	5083	19.92	24.50	796
LSD (.05)	519	538	1.65	.79	171
F. Value	6.16	4.83	7.88	1.67	1.32
C. V. %	7.79	9.16	7.17	4.73	18.55

\* - Known Sugar Loss

Source	D.F.	Gross Sugar	Gross Sugar - KSL	Tons Beets/A	% Sugar	Impurity Index
Replications	5	143,430	416,506	5.2307	24.9272	219,438
Varieties	15	1,116,979	892,944	14.5533	24.6298	22,965
Error B	18	311,953	503,601	3.0864	24.7665	126,198
Error E	57	181,415	184,718	1.8476	24.3764	17,425
Total	95					

Design: 4 x 4 Triple Lattice, 16 entries, 6 replications.  
 Plot Size: 2 row plots, 35 feet long, 22 inch rows.

Planted: May 13, 1971  
 Harvested: October 20, 1971

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beets /A	% Sugar	Impurity Index
SL (129 x 133) ms x SP 6322-0	5997	5204	21.26	14.01	888
SP 67533-1 x SP 6322-0	5343	4666	18.63	14.26	826
SP 67588-2 x SP 6322-0	5312	4641	19.06	14.01	903
(VI 1861 x SL 133) x 02 Clone	5816	4976	20.69	14.16	967
(VI 100363 x SL 133) x 02 Clone	5807	5020	20.41	14.23	926
(VI 1861 x SP 6423-0) x 02 Clone	5596	4946	19.68	14.29	781
(VI 100363 x SP 6423-0) x SP 6822-0	5500	4734	20.34	13.69	919
(VI 1861 x SL 133) x SP 6822-0	5810	4944	21.37	13.71	986
(VI 100363 x SL 133) x SP 6822-0	5715	4849	21.07	14.45	1011
(VI 1861 x SP 6423-0) x SP 6822-0	5661	4947	20.36	13.95	851
(AI-1 x AI-2) ms x 74842	5525	4875	19.18	14.56	783
SP 6423-01 x 74832	5667	4879	19.99	14.28	891
(SL 129 x 63-6) x C-413	5753	5025	19.86	14.32	852
(63-8HO x FC 502) x C-413	5598	4900	19.00	14.62	852
63-(5HO x 6) x C-413	6256	5323	22.80	13.85	1031
63-5HO x C-713	5828	5026	20.30	14.46	928
Overall Mean	5701	4935	20.25	14.12	900
LSD (.05)	427	418	1.35	.55	108
F. Value	2.59	1.66	5.33	3.48	4.82
C. V. %	6.49	7.33	5.77	3.39	10.39
* - Known Sugar Loss					
Source	D/F	Gross Sugar	Gross Sugar - KSL	Tons Beets/A	% Sugar
Replications	5	125,659	721,378	10.0329	8.2682
Varieties	15	321,576	185,155	6.7917	.6443
Error B	18	205,414	297,704	1.7722	1.0521
Error E	57	123,948	111,783	1.2732	.1852
Total	95				6,944

Variance Table

Source	D/F	Gross Sugar	Gross Sugar - KSL	Tons Beets/A	% Sugar	Impurity Index
Replications	5	125,659	721,378	10.0329	8.2682	481,108
Varieties	15	321,576	185,155	6.7917	.6443	33,446
Error B	18	205,414	297,704	1.7722	1.0521	62,124
Error E	57	123,948	111,783	1.2732	.1852	6,944
Total	95					

Design: 4 x 4 Triple Lattice, 16 entries, 6 replications.

Plot Size: 2 row plots, 35 feet long, 22 inch rows.

Planted: May 13, 1971

Harvested: October 14, 1971

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beets /A	% Sugar	Impurity Index
SL (129 x 133) ms x SP 6322-0	6680	5876	22.86	14.64	804
(UI 100363 x 2161) x 02 Clone	6409	5736	20.86	15.37	700
UI 1861 x SP 6528-01	6507	5887	21.08	15.42	639
(SP 64502-01 x SP 6442-0) x 02 Clone	6120	5504	19.04	16.06	676
UI 1861 x 02 Clone	6939	6384	21.54	16.12	630
(SL 129 x 133) x 02 Clone	6573	5844	21.26	15.48	742
UI 1861 x SP 6423-0	6759	6131	21.12	16.02	620
UI 100363 x SP 6423-0	6280	5658	20.24	15.50	660
(UI 12163 x SP 6121-0) x SP 6322-0	5945	5154	20.36	14.33	795
(SP 6121-01 x UI 12163) x SP 6322-0	6574	5875	21.28	15.45	709
SL 133 x 02 Clone	6427	5643	21.10	15.25	812
(SP 6423-01 x EL 35) x 02 Clone	6291	5633	20.43	15.49	690
(SP 64502-01 x SP 673465-0) x 02 Clone	5908	5239	18.91	15.63	756
SP 673465-01 x CT 7	6124	5520	19.31	15.86	658
SP 67550-02 x SP 6322-0	6312	5745	19.39	16.28	602
Overall Mean	6383	5715	20.59	15.53	699
LSD (.05)	606	563	1.97	.67	101
F. Value	2.02	2.22	2.40	4.98	3.65
C. V. %	8.24	8.54	8.29	3.73	12.59

\* - Known Sugar Loss

Source	D/F	Gross Sugar	Tons Beets/A	% Sugar	Impurity Index
		- KSL			
Replications	5	176,576	282,079	1.5878	.4197
Varieties	11	558,815	529,254	7.0061	1.6698
Error	69	276,618	238,436	2.9137	.3355
Total	88				7,754

Design: Randomized Block, 15 entries, 6 replications.  
 Plot Size: 2 row plots, 35 feet long, 22 inch rows.  
 Planted: May 13, 1971  
 Harvested: October 18, 1971

## By American Crystal Sugar Company

Variety	Gross Sugar Lbs./A	Gross Sugar - KSL*	Tons Beets /A	% Sugar	Impurity Index
(562 HO x 546) x C-413 (US H9B)	7183	6535	22.56	15.99	597
(562 HO x 569) x Y 801	6433	5746	19.83	16.22	721
(718 H32 x 714) x Y 801	7351	6506	22.85	16.07	787
(563 HO x 546) x Y 904 A	7294	6577	22.94	15.88	659
(716 H29 x 718) x Y 904 A	6738	6048	21.02	16.02	707
(563 HO x 546) x Y 904 B	7017	6330	21.61	16.23	655
(563 HO x 546) x 944	6722	6081	21.12	15.96	632
(705 H25 x 718) x Y 804	6813	6118	21.16	16.11	674
SL 133 x C-413	6606	6004	20.17	16.39	609
68-313 ms x C-413	6081	5455	19.24	15.77	690
680314 ms x C-413	7095	6307	22.12	16.07	743
546 HO x C-813 T	6192	5480	20.01	15.42	794
546 HO x 55-205-0	6410	5713	20.30	15.74	750
66-569 H3 x 64-208	6347	5721	18.94	16.67	684
68-313 ms x C-813 T	5566	4970	17.50	15.87	738
68-315 ms x C-813 T	6095	5469	19.16	15.89	701
68-316 ms x C-813 T	6945	6126	21.79	15.91	821
SL (129 x 133) ms x C-813 T	5972	5394	18.44	16.17	659
Overall Mean	6603	5921	20.60	16.02	701
LSD (.05)	874	834	2.76	.57	144
F. Value	2.61	2.34	2.56	1.79	1.51
C. V. %	11.52	12.28	11.69	3.10	17.93
Variance Table					
Source	D/F	Gross Sugar	Tons Beets/A	% Sugar	Impurity Index
Replications	5	7,848,229	<u>7,905,053</u>	61.2905	1,3376
Varieties	17	1,512,116	1,238,338	14.8378	221,964
Error	85	578,847	528,402	5.7991	23,813
Total	107				15,807

\* - Known Sugar Loss

Design: Randomized Block, 18 entries, 6 replications.  
 Plot Size: 2 row plots, 35 feet long, 22 inch rows.  
 Planted: May 18, 1971  
 Harvested: October 9, 1971

Screening Breeding Lines for Disease Resistance, East Lansing, 1971.

C. L. Schneider and G. J. Hogaboam

1. Black root disease - Screening tests of 160 lines were conducted in the greenhouse from December 1970 through April 1971. Dry oospore inoculum of Aphanomyces cochlioides was added to each 4-in. pot at time of seeding at the rate of 5-10 ml per pot. Each test of 12 entries included commercial variety US H20 as a standard for comparison. Five pots of each entry were planted, and each pot normally contained 10-15 seedlings. Six weeks after planting each plant was assigned a disease severity rating from 0 (no symptoms) to 5 (dead). Average disease ratings for each entry and LSD for each experiment were computed. The average disease ratings for variety US H20 in the 16-test series ranged from 2.3 - 3.8 (avg. = 3.2). Most of the entries (81.8%) received ratings that did not differ significantly from that of US H20; 6.9% received superior ratings and 11.3% received inferior ratings.
2. Rhizoctonia crown and root rot - Breeding lines (198) were screened for resistance in field plots. There were six experiments comprising 33 entries and three check varieties in single row plots, 20 ft long with 3 replications. On 9 June, shortly before thinning, dry barley inoculum was applied along side the rows at the rate of 3 ml per ft of row about  $\frac{1}{2}$  in. deep with a Planet Jr. seeder. On 16 July and 3 August dried inoculum (3 ml per ft of row) was thrown by hand into the crowns of plants in some of the plots. All plots were exposed to the side-dress inoculum; while 0-3 plots of each entry were exposed to the inoculum applied in the crowns. In October all plots were harvested and each root was assigned a disease rating of either 0 (healthy), .5 (diseased) or 1 (dead) and average disease ratings were computed. At each inoculation level there were differences in disease ratings between the entries. (Table 1). Entries derived from Ft. Collins lines with a history of selection for Rhizoctonia resistance, (Experiments 3 and 9) appeared superior to the majority of entries. Healthy roots were selected in each experiment as possible sources of Rhizoctonia resistance.
3. Cercospora leaf spot - Entries were screened in field plots, each 20 ft long. There were eight experiments, according to breeding type with 3 replications each. Commercial check varieties were included in each experiment as standards of grading. On 1 July the plots were infested with finely ground dried sugarbeet leaf inoculum, applied with a Soloport duster at the rate of 24 liters per acre. The subsequent disease reached maximum intensity on about 15 September when disease ratings were assigned. The majority of the entries were classified as more resistant than the check varieties (Table 2). The disease nursery also provided a means of selecting for Cercospora resistance.

Table 1. Disease ratings at several inoculation levels of entries in 1971 Rhizoctonia nursery - East Lansing, Michigan.

Exp. No.	Types	Inoc- ulation level	No. Entries	Disease Rating Range	Av. Disease Rating	Av. Disease Rating of Check Vars.	
						1	2
1)	MM Beltsville	1	4	36-54	41.8		
		2	13	11-62	43.9	55	
		3	11	38-72	51.5		42
		4	5	43-64	54.2		
		T	33		47.7		
2)	mm Beltsville	1	4	19-55	36.8		
		2	13	13-63	40.3	52	
		3	11	39-63	49.5		33
		4	5	40-70	58.6		
		T	33		45.7		
3)	mm 0-type E.L.	1	3	20-62	38.3		
		2	8	39-75	53.8	46	
		3	5	40-77	65.6		41
		4	2	32-71	81.0		
		T	18		57.5		
	Rhizoc res. mm	1	1	-	7.3		
	field sel. for	2	5	13-31	17.8		
	Aphanomyces res.	3	6	17-42	31.5		
		4	2	32-34	33.0		
		T	14		25.1		
	68B125 MM		1		73.7		
4)	mm E.L.	1	4	5-31	18.3		
		2	13	16-46	31.4	47	
		3	11	39-66	49.6		41
		4	5	45-72	61.8		
		T	33		40.5		
5)	mm E.L.	1	4	12-27	21.8		
		2	13	21-50	35.3	45	
		3	11	28-68	47.4		51
		4	5	53-73	64.6		
		T	33		42.1		
9)	$F_2$ of BRR-LSR x Rhizoc. res. from Beltsville	1	4	20-25	21.8		
		2	13	12-53	27.0	60	
		3	11	34-64	53.5		43
		4	4	56-62	59.5		
		T	32		39.5		
	FC701-5 (Rhizoc. res.)	3	1		28.0		

a/ Inoculation levels: 1 = Rhizoctonia inoculum - sidedressed in soil  
 2 = " " " " " " + in crowns of 1 rep.  
 3 = " " " " " " + " " " " 2 reps.  
 4 = " " " " " " + " " " " 3 reps.

b/ Disease rating =  $(\text{No. plants healthy} \times 0) + (\text{No. plants diseased} \times 5) + (\text{No. plants dead} \times 1.0) \times 100$   
 Total No. plants inoculated

Results expressed as means of three, single-row plots, each 20 ft long.

c/ Check variety 1 = UI(1861x2161)xSP6322-0  
 " " 2 = SP69550-01xSP6322-0

Table 2. Results of screening breeding lines for resistance to leaf spot disease in Cercospora beticola nursery, East Lansing, Michigan, 1971: Number of entries in each indicated disease rating class.

Exp. No.	Type	Disease rating (in pct of check varieties) <sup>1/</sup>						No. entries	Av. disease rating of check varieties
		45-54	55-64	65-74	75-84	85-94	95-104		
1) MM	Beltsville	2	2	12	11	3	2	1	-
2) mm	Beltsville	-	2	11	14	4	2	-	-
3) mm	0-type, E.L.	-	1	6	8	3	-	-	3.8
Rhizoc.res.mm field sel. BRR	-	1	5	5	1	2	-	-	3.1
4) mm	E.L.	-	-	3	9	20	1	-	-
5) mm	E.L.	-	1	23	5	2	2	-	3.6
6) Variety screening test entries	-	1	-	1	4	2	4	2	33
7) Reciprocal hybrids	-	2	3	1	7	-	1	-	14
8) Hybrid evaluation test entries	-	4	10	7	2	5	-	-	28
		2	14	73	62	46	16	6	221

Sugarbeet Disease Investigations - 1971

C. L. Schneider

1. Aphanomyces cochlioides oospores.

Oospores have been used to initiate experimental infection of sugarbeet plants with the black root disease fungus, Aphanomyces cochlioides. The most satisfactory medium for oospore production thus far has been .5% oatmeal homogenate broth, adjusted to pH 6.5. In media below pH 6.0 and above pH 7.0 oospore production is sharply reduced. Light has been found to suppress oospore production, therefore cultures are incubated in the dark. Isolates of the fungus differ in ability to produce oospores in the oatmeal medium, hence cultures have been assayed in order to select the most prolific spore producers. Dried oospores initiated infection after four years storage at 5°C but infectivity was markedly reduced after the second year. No differences in infectivity was noted among lots of dried oospores stored at 25, 5 and -9°C.

2. Rhizoctonia solani investigations.

a. Comparison of isolates - Stecklings of ~~seven~~ sugarbeet cultivars differing in Rhizoctonia resistance were separately inoculated with eight of the most virulent among 36 Rhizoctonia solani isolates from sugarbeets in Michigan and Ohio soils. Differences in virulence between the isolates were noted. Differences between the cultivars in degree of susceptibility were relatively the ~~same~~ with each isolate tested. There was no indication of physiologic specialization among the group of isolates tested, but this study is being continued with additional isolates of the fungus.

b. Greenhouse testing of Rhizoctonia resistance - Differences in Rhizoctonia resistance between sugarbeet cultivars have been noted in greenhouse inoculation tests when inoculum is applied after the plants have passed the seedling stage. In 1971 attempts were made to test differences between resistant and susceptible types in the seedling stage. Variations in type of inoculum, dosage, timing and placement of inoculum were tested. Under the conditions of the tests, seedlings of the resistant cultivars succumbed to infection and damped off as readily as the susceptible cultivars and no differences in resistance were apparent at this stage of growth.

c. Effect of soil in crowns on root rot - In the course of giving the sugarbeet crop a final cultivation, some growers purposely cause soil to be thrown around the bases of the plants and into the crowns. A study was made to determine the effect of this practice in development of Rhizoctonia root rot. In mid-August, soil was lifted from between the rows with a spade and thrown into the ~~crowns~~ of plants in plots previously infested with dried grain cultures of R. solani. At harvest time it was evident that plants that received the soil in the ~~crowns~~ had considerably more Rhizoctonia root rot than the untreated controls. The average root

rot indexes, ranging from 0 (healthy) to 1.0 (dead) of two varieties based on three 20 ft plots of each treatment were as follows:

Variety	Root rot index	
	Soil	Control
701/1 (Rhizoctonia-resistant)	.25	.10
6822-0 (Rhizoctonia-susceptible)	.85	.56

3. Screening tests of chemicals and biologicals for disease control.

a. Aphanomyces root rot - Seven soil treatments and three seed treatments were tested in field plots naturally infested with the pathogen. The following were applied in rows immediately before planting: NH<sub>4</sub>OH, Urea, Sodium-p-(dimethylamino) benzenediazotol sulfonate (DASS), DMTT, Sodium-N-methyl dithiocarbamate and dried cabbage plants. DASS, applied at 12.6 and at 50 ppm was the only treatment that provided control throughout the season. There was some indication of control early in the season with the dried cabbage. The most effective seed treatments were also those that contained DASS.

b. Rhizoctonia root rot. Chemical soil treatments were tested in plots in which sugarbeets, artificially inoculated with R. solani, had grown in 1970. The following were ineffective in controlling the disease: 1, 3, Dichloropropene + chloropicrin soil fumigant (15 and 30 gal/A.); 2-chloro-6-(trichloromethyl) pyridine nitrification stabilizer (0.25 and 0.5 lb/A), applied with 8-32-16 side-dressed fertilizer; and PCNB fungicide (8 and 16 lb/A). Among 23 chemical treatments applied as sprays directed into the crowns of plants in plots artificially infested with R. solani inoculum, the following significantly reduced root rot: PCNB (2 and 4 lb a.i.a.) and chlorothalonil (1.5 lb a.i.a.).

c. Cercospora leaf spot - Twenty-three chemical spray treatments were tested in plots artificially infested with Cercospora beticola dried leaf inoculum. A total of four (14-day frequency) or three 21-day frequency sprays of each treatment were applied. At the peak of the epiphytotic, unsprayed control plots had a disease rating of 4.0, based on an index ranging from 0 (healthy) to 9 (dead). Benomyl (3 oz a.i.a.) and thiophanate-methyl (5.6 and 8.4 oz) gave the best control among the various treatments, even at 21-day schedules, each with a disease rating of 1.4. Addition of sticker spreaders and spreader-activators to benomyl, thiophanate-methyl and thiabendazole did not increase their efficacy.

4. Aerial spray tests for control of Cercospora leaf spot - Cooperative tests with H. S. Potter, (Michigan State University), Phil Brimhall (Northern Ohio Sugar Co.) and F. B. Russell (Buckeye Sugars) were conducted at three locations in southern Michigan and northern Ohio. Different types of aircraft and spray apparatus were used at the different locations. The number of applications did not exceed two, and all except one treatment was applied at the rate of 4 gal/A. Average leaf spot ratings

of unsprayed control plots at Ida, Michigan (25 Sept.) = 4.3; Green Springs, Ohio (12 Oct.) = 5.0; Ottawa, Ohio (13 Sept.) = 3.3. All of the chemicals tested gave satisfactory control and included: benomyl 4 oz a.i.a.), thiabendazole (4 oz), triphenyl tin hydroxide (2.38 oz and 4 oz), cupric hydroxide + oil (1.72 lb) and cu ammonium carbonate (.39 lb/A.). One application of benomyl (6 oz) gave satisfactory control at ~~one~~ of the three locations tested. Application of benomyl at 2 gal. spray/A. ~~was~~ ~~an~~ effective ~~in~~ 4 gal.

### Developing Varieties With Better Storage Characteristics

R. C. Zielke

Previous work has shown that impurity constituents in stored beet roots may vary considerably depending upon the length of storage time and temperature, agronomic practices, and varietal characteristics. The ~~more~~ dynamic impurities found in stored roots are reducing sugars (invert) and raffinose. Smaller fluctuations can occur in the amino acids, potassium, sodium, betaine, and chloride fractions.

Research was initiated this past year to determine accurate methods and techniques of sampling individually stored roots for impurity concentrations and assessing the changes which occur over the storage period. The object of this study is to determine if ~~some~~ of the changes which occur during the storage period can be genetically controlled. If so, a "storage" beet could be developed which would be characterized by insignificant changes in impurities while the roots are in storage piles. Most of the roots are presently undergoing storage treatments and pertinent data are not yet available.

PHYSIOLOGICAL INVESTIGATIONS - 1971

F. W. Snyder

Germination Studies

I. Effect of Maturity on Water Absorption by Sugarbeet Fruits: Fruits from individual plants (five cultivars, 11 plants) were harvested at 40, 50, 60, and 70 days after first bloom. Fruit moisture at harvest, and water absorption in 40 hr by the air dried fruits after no treatment, after soaking for 2 hr then dried to equilibrium in air, and after hand-processing, were measured. Percent water absorption =

$$\frac{\text{Wet wt} - \text{Air dry wt}}{\text{Air dry wt}} \times 100.$$

Fruits harvested at 40 days absorbed 143, 120, and 79% water, while at 70 days they absorbed 117, 115, and 43% for untreated, soaked, and processed fruits respectively. The 50- and 60-day values for untreated and processed fruits were intermediate. Fruits from different plants which had received the soak-treatment were not consistent, ~~some~~ absorbed more and ~~some~~ less water than the untreated fruits.

A hydrophilic compound(s) in the fruit, which may be converted to a less active entity as the fruit dries while attached to the plant, is postulated. Also during the soak-treatment the compound(s) may be converted into a more active entity in fruits of ~~some~~ plants and in others either leached out or into a less active entity. Water absorption by dried fruits was positively correlated with fruit moisture at harvest (1% level for processed fruits at all harvests). Water absorption by the fruit and fruit moisture at harvest were negatively correlated with germination percentages, for ~~some~~ harvests and treatments significantly so. The data suggest that fruit moisture at harvest and water absorption by immature fruits may be genetically controlled.

II. Relation of Maturity to Weight Losses in Treated Fruits: Samples of fruits, harvested at 40, 50, 60, and 70 days after first bloom, were weighed before and after hand processing and before a 2 hr soaking in water and then after regaining air-dry equilibrium. As maturity progressed, the weight losses by soaking (loss of water soluble substances) decreased; in contrast, the weight losses by processing increased. Approximately a quarter of the fruit weight was removed by hand-processing mature fruits. The data suggest that the fruit characteristics associated with weight losses may be under genetic control.

III. Germination Response to Time of Harvest: The germination percentages for five cultivars suggest that at full maturity it is very difficult to select cultivars with the best germination (See the percentages under "P" in various columns of Table 1). At 60 and 70 days from first bloom, four of the cultivars germinated in ~~excess~~ of 90%, but at 50 days only three and at 40 days only one. Since seeds of certain plants and cultivars attain physiological maturity (i.e., they will germinate) much sooner after first bloom than others, using the technique of progressive

Table 1. Relation of germination to time of harvest and treatment of sugarbeet fruits.

Cultivar	No. of plants	Treat. @	40			50			60			70		
			U	S	P	U	S	P	U	S	P	U	S	P
			No. days from first bloom			No. days from first bloom			No. days from first bloom			No. days from first bloom		
1	2		47	42	46	57	68	72	80	87	84	78	90	95
2	3		92	94	87	93	96	97	92	97	99	97	98	100
3	1		100	100	96	97	99	97	100	100	100	100	100	100
4	2		72	94	83	69	95	93	86	99	96	86	99	97
5	3		57	79	60	80	89	82	84	95	92	93	96	99

© U is untreated, S is soaked, P is processed.

harvests could isolate the plants which produce early maturing seeds. Cultivars having this trait would be much less sensitive to reasonable fluctuations in time of harvest.

**IV. Germination Response to Fruit Treatment:** Germination patterns for cultivars may differ significantly in response to a given set of treatments, particularly for the earlier seed harvests. For cultivars 1, 2, and 3, seeds germinated rather consistently for all three treatments (Table 1). Neither soaking nor processing aided germination over the untreated for the 40-day harvest, yet cultivar 1 germinated less than 50% while cultivars 2 and 3 germinated at least 90%. Seeds of cultivar 1 may have been physiologically immature at 40 days.

Germination appeared to be stimulated more by soaking than by processing at 40 days from first bloom in cultivars 4 and 5. In cultivar 5, processing did not improve germination over the untreated for the 40- and 50-day harvests. In cultivar 4, processing increased germination somewhat at 40 days and at 50 days equalled soaking.

When testing cultivars with unknown germination responses, more reliable germination percentages should be attainable when "seeds" are prepared in the same way they are used by the grower, i.e., unsoaked, processed "seeds".

**V. Relation of Fruit Moisture at Harvest and Germination in Cultivars:** At 40 days after first bloom cultivars differed significantly in fruit moisture at harvest, e.g., 258 to 147% for four cultivars with at least two plants per cultivar. Both fruit moisture and germination percentages tended to cluster when plotted graphically, which suggests that these may be related. The pattern is less distinct by the 50-day harvest and because of continued moisture loss with maturity, no pattern is apparent at maturity. It is possible that the early loss of fruit moisture on healthy plants may be related to early seed maturity.

From studies on the effect of maturity on germination in various cultivars, the evidence seems clear that sugarbeet fruits and seeds differ much less in any given characteristic at full maturity than at the more immature stages. Since the significant criteria for superior germination performance are much more difficult to detect in fully mature fruits and seeds, studies to determine the significant criteria apparently should be made on immature fruits and seeds.

#### Leaf-area Accretion Studies

**Growth Chamber Experiments:** Plants were grown in vermiculite with an excess of complete mineral nutrient solution applied daily. The plants were exposed to 14 hr of light and 10 hr of dark. Plants were rotated about the chamber every two days.

**I. Effect of Temperature on Leaf-area Accretion:** US H20 was grown in 16 oz thermal containers for approximately 20 days at a number of different temperatures in a more controlled series of experiments than reported in Sugarbeet Research, 1970 Report. The high temperature corresponded

to the light period and the low temperature to the dark period. For the series of experiments the fluorescent lamps had a somewhat lower output as measured by foot candles (ft-c) but the spectrum more closely approached that of the sun. The average light intensity was estimated as closely as possible from the measurements. Twenty-four plants were grown and measured for leaf area for each temperature. The leaf area for 20 days after emergence was determined for each temperature regime by graphing leaf area against age on semi-log paper.

The new series of data indicate that leaf area accretion is fully responsive to temperature over the whole range of temperatures tested (Table 2). Temperature during the dark period had a very significant effect on accretion.

When plants are grown at small differences in temperature, the slopes of the graphs for leaf area accretion may be so similar for 10- to 15-day periods that significant differences in growth rate may not be apparent until after longer periods of growth. (See 10- and 20-day leaf areas in Table 2). This was one of the difficulties in detecting effects of temperature on accretion as reported in 1970.

**II. Comparison of Seedlings For Leaf Area And Root Weight Accretion:** Individual plants varied greatly in leaf area and root weight, also root weight and leaf area of a plant did not correlate very highly (2). Seedlings also differed markedly in leaf area and root weight at about 30 days after emergence as indicated by the size of the coefficients of variation (Table 3). The cultivars in Expt. 29 differed appreciably in both leaf area and root weight. For all experiments and cultivars, the coefficients of variation for root weight were much higher than those for leaf area (Table 3). (Coefficients of variation for leaf weight and shoot weight were similar to those for leaf area.)

Correlation coefficients (Table 4) again confirm that in 25- to 30-day old seedlings root weight does not correlate very highly with leaf area and weight. US H20 seems to correlate lower than a number of the cultivars. The high correlation between leaf area and leaf-blade weight (0.84 to 0.97) indicates that fresh leaf-blade weights could be used to screen plants for leaf area accretion. This would save considerable time as compared with planimetering to determine leaf area.

The early development of differences in root weight for the cultivars in Experiments 29 and 30 (Table 3) suggest that as little as 60 to 90 days growth in the field might be sufficient to screen out the lower quarter or third of the cultivars that have low root yield.

**III. Environmental Versus Genetic Variability:** A major problem in studying the growth of individual plants of a cultivar is determining what caused the observed differences. Particularly from the physiological point, how much of the differences are caused by environment and how much by genetic constitution? When single plants per pot were grown for about 30 days, the coefficients of variation (CV) for leaf area and leaf

Table 2. Effect of temperature on leaf area accretion of cultivar US H20. Plants grown for 20 days after emergence in growth chambers.

Chamber	Temperature regime			Avg light Ft-c	Leaf area per plant after 10 20 days		Approx. doubling time*
	Cycle	C	F		Cm <sup>2</sup>	Cm <sup>2</sup>	
A	15-5	11	52.	1,590	1.3	5.4	5
B	20-10	16	61.	1,725	3.1	29.5	3 1/4
B	20-15	18	64.5	1,725	3.8	55.	2 5/8
A	25-15	21	70.	1,595	6.9	95.	2 3/4
A	25-20	23	73.5	1,460	8.1	230.	2 1/4
A	30-20	26	79.	1,425	9.7	350.	2

\* No. of days for leaf area to double, e.g. 2, 4, 8, 16, 32, 64, etc.

Table 3. Leaf area and root weight for some cultivars grown in growth chambers.

Expt.	Cultivar	No. of plants	Days growth	Leaf Avg Cm <sup>2</sup>	Root weight Avg G.	Ratio of growth Leaf area	Ratio of Field root yield T/A
				C.V. %	C.V. %		
28	US H20	40	30	465±74	15.9	2.95±0.90	30.5
29	A	20	29	792±121	15.2	3.51±0.80	22.8
29	B	20	29	711±121	17.0	3.20±0.73	22.8
30	C	18	25	614±103	16.8	2.60±0.66	25.4
30	D	20	25	604±123	20.4	2.48±0.62	25.0
41	E	40	26	560±121	21.6	2.29±0.72	31.4

Table 4. Correlation coefficients for root and shoot characters for seedlings of some cultivars.

Expt. no.	Cultivar	Degrees freedom	Characters	Leaf area	Leaf blade wt	Shoot wt
Root wt						
28	US H20	38		0.47**	0.47**	0.45**
29	A	18		0.49*	0.65**	0.71**
	B	18		0.55*	0.53*	0.52*
30	C	16		0.62**	0.61**	0.69**
	D	18		0.66**	0.80**	0.82**
41	E	38		0.74**	0.76**	0.78**

Table 5. Relationships when two plants are grown in a pot, 40-pot experiments.

Plants/pot	US H20		SP6600
	1	2	2
Days after emergence	30	19	22
Leaf area per pot, Mean $\text{cm}^2$	464.6 $\pm$ 74.0	286.6 $\pm$ 53.1	393.3 $\pm$ 75.4
Coefficient of variation	15.9	18.5	19.2
Leaf area larger plant in pot	-	161.1 $\pm$ 30.2	217.7 $\pm$ 40.7
Coefficient of variation	-	18.7	18.7
Leaf area smaller plant in pot	-	125.6 $\pm$ 28.0	179.6 $\pm$ 41.4
Coefficient of variation	-	22.2	23.0
Mean difference in leaf area between plants in pot	-	35.4 $\pm$ 23.8	37.1 $\pm$ 30.3
Coefficient of variation	-	67.1	81.7

and shoot fresh weights ranged mainly between 13 and 18% for a number of cultivars. Leaf areas also were obtained from these same plants at earlier stages of growth by means of grids. The CV gradually decreased with increasing age of the seedlings. This does not seem to be related to the method of determining leaf area or precision of measuring. (In three of these experiments, CV for root weight ranged between 23 and 31%.)

The CV appears to be distinctly larger when environment deviates from ~~more~~ optimum conditions, increasing from a value of about 18% to about 25% when the light in the growth chamber ~~was~~ reduced by half. As the ~~mean~~ temperature for a series of growth experiments ~~was~~ decreased from 23 to 11 C, the CV increased from a value of about 13% at 23 C to about 28% at 11 C.

There is no way to determine the components of variability when only one plant is grown in a pot. If two plants are grown in a pot, then the total growth per pot and the growth per plant can be compared. If the environment of the growing medium in the pot is causing the variations between pots, then the two plants should respond to nearly the same degree. If genetic differences are involved, then fairly large differences between the plants in a given pot should occur some of the times.

Two plants per pot were grown in 6 1/4 by 6 3/4 in. plastic pots using cultivars US H20 and SP6600. The period of growth was shortened to minimize mutual shading and severe competition between the two plants in a pot.

The CV on a per pot basis, without regard for the number of plants per pot, did not vary greatly (Table 5). While the CV for the larger plant was very close to that for the two plants taken as a unit, the data suggest that the CV for the smaller plant in each pot did increase somewhat. The ~~mean~~ difference in leaf area between plants in a pot with its very large standard deviation suggests that genetic differences between plants do exist and on the basis of the size of the CV a sizeable part of the CV obtained for single plants in a pot should be attributed to genetic variation. Cope (1), working with Lespedeza cuneata (Dumont) G. Don, points out that the expression of heterosis is much greater under competitive than under non-competitive plant spacing. Such a reaction could increase the size of the CV when two sugarbeet plants were grown in a pot.

The cause of plant to plant differences is still not clear, but it appears that ascribing the major cause of differences to environmental factors may be incorrect.

Cooperative Research - F. W. Snyder, M. Joyce (Hallett) Abbate, and N. E. Tolbert

I. Relation of CO<sub>2</sub> Compensation Point to Physiological Age of Sugarbeet Leaves.

In a closed system, the CO<sub>2</sub> compensation point ( $\Gamma$ ) in ppm CO<sub>2</sub> is at equilibrium for a given light intensity, temperature, and CO<sub>2</sub> and O<sub>2</sub> concentrations.  $\Gamma = \text{CO}_2$  evolved by dark respiration and photorespiration minus the CO<sub>2</sub> re-fixed by photosynthesis.

Sugarbeet has photorespiration and the enzyme ribulose di-phosphate (RuDP) carboxylase for capturing the CO<sub>2</sub> for photosynthesis. RuDP carboxylase is not very efficient, thus the  $\Gamma$  for mature sugarbeet plants is about 60-65 ppm of CO<sub>2</sub>. At least by implication  $\Gamma$  is supposed to be very constant for sugarbeet, however we found that  $\Gamma$  varies greatly, depending on the physiological age of the leaf (Table 6). Young leaves have very high values for  $\Gamma$  and also higher dark respiration. Apparently a sugarbeet leaf does not have full photosynthetic capability until after it has enlarged considerably.

II. Enzymes in Sugarbeet Leaves.

Data on the effect of temperature, physiological age and field growth on the enzymes 3-phosphoglyceric acid phosphatase and phosphoglycolate phosphatase are being compiled for publication. M. Joyce Abbate will be senior author.

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Table 6. Relation of  $\text{CO}_2$  compensation point to physiological age of sugarbeet leaves.

Plant age	Area/ leaf	Physiological age	$\text{CO}_2$ compens. point	Dark respiration
	$\text{cm}^2$		ppm	$\text{ppm } \text{CO}_2 \text{ min}^{-1} \text{ cm}^{-2}$
A	1	very young	373	2.06
90 days	4 7	young	202 179	1.49 1.27
	21	intermediate	89	1.14
	68 175	mature	63 65	1.01 0.50
<hr/>				
B	8 12	young	263 215	1.76 2.09
125 days	38 65	intermediate	165 122	1.65 1.48
	415 607 626	mature	61 64 63	0.75 0.97 0.79

## GRAVEL AND FIELD EMERGENCE STUDIES

F. W. Snyder and R. C. Zielke

The gravel emergence technique (See page E35, Sugarbeet Research, 1970 Report) has been used to compare blotter germination with gravel emergence for about 80 seedlots. Four of them (by chance they were from a single cultivar) were selected for field emergence tests<sup>1</sup>. Data (Table 1) indicate generally high blotter germination, low field emergence, and a large range in gravel emergence. Also, the range in blotter germination was greater than the range in field emergence.

The gravel emergence tests were assumed to measure the ability of seedlings to overcome physical impedance to emergence. If this is true, the field emergence should relate more closely to gravel emergence than to blotter germination. Although the field emergence was much less, it more closely paralleled blotter germination than gravel emergence (Table 1).

The gravel used in this emergence test holds about 5% of water on its surface, depending on how completely the excess water drips off. Since differential sensitivity to the amount of water surrounding the "seed" seemed a likely possibility in affecting the percentage emergence from gravel, experiments were designed to test this.

When the moisture available to the seeds was varied in three different gravel experiments, the percentage emergence from gravel for seedlot A ranged from a low of 81 to a high of 94% and for seedlot D from a low of 35 to a high of 72% (Right side of Figure 1). A confirmatory experiment of the effect of blotter wetness on germination is plotted on the left side of Figure 1. After soaking for 1 hr in water, seedlot A had absorbed 22% and seedlot D 34% water. After 30 hr, seedlots A and D had absorbed 31 and 34% water, respectively, when on relatively dry blotters and 37 and 47% water on very wet blotters.

The data show that seedlot D is affected very significantly by an excessive amount of available water during germination, whereas seedlot A is much less sensitive. When the seedlots were placed on very dry blotters, seedlot D seemed less able to germinate than seedlot A.

Since these seedlots represent a single cultivar, differences in germination and emergence must be ascribed mainly to the effects of time of harvest, e.g., maturity effects on germination and on water absorption(1, 2), and differences in field environment during seed maturation.

<sup>1</sup> The Michigan and Ohio Sugarbeet Industry aided us in conducting these tests.

The lower percentages of emergence from gravel as compared with blotter germination indicate that the gravel test does develop some physical impedance to normal germination and emergence, even when the available moisture is favorable.

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Table 1. Germination and emergence response of four seedlots of one sugarbeet cultivar.

	Seedlot			
	A	B	C	D
Blotter germin. %	98	99	95	80
Gravel emergence %	93	74	51	54
Field emergence %	52	51	48	41
Average 6 tests				

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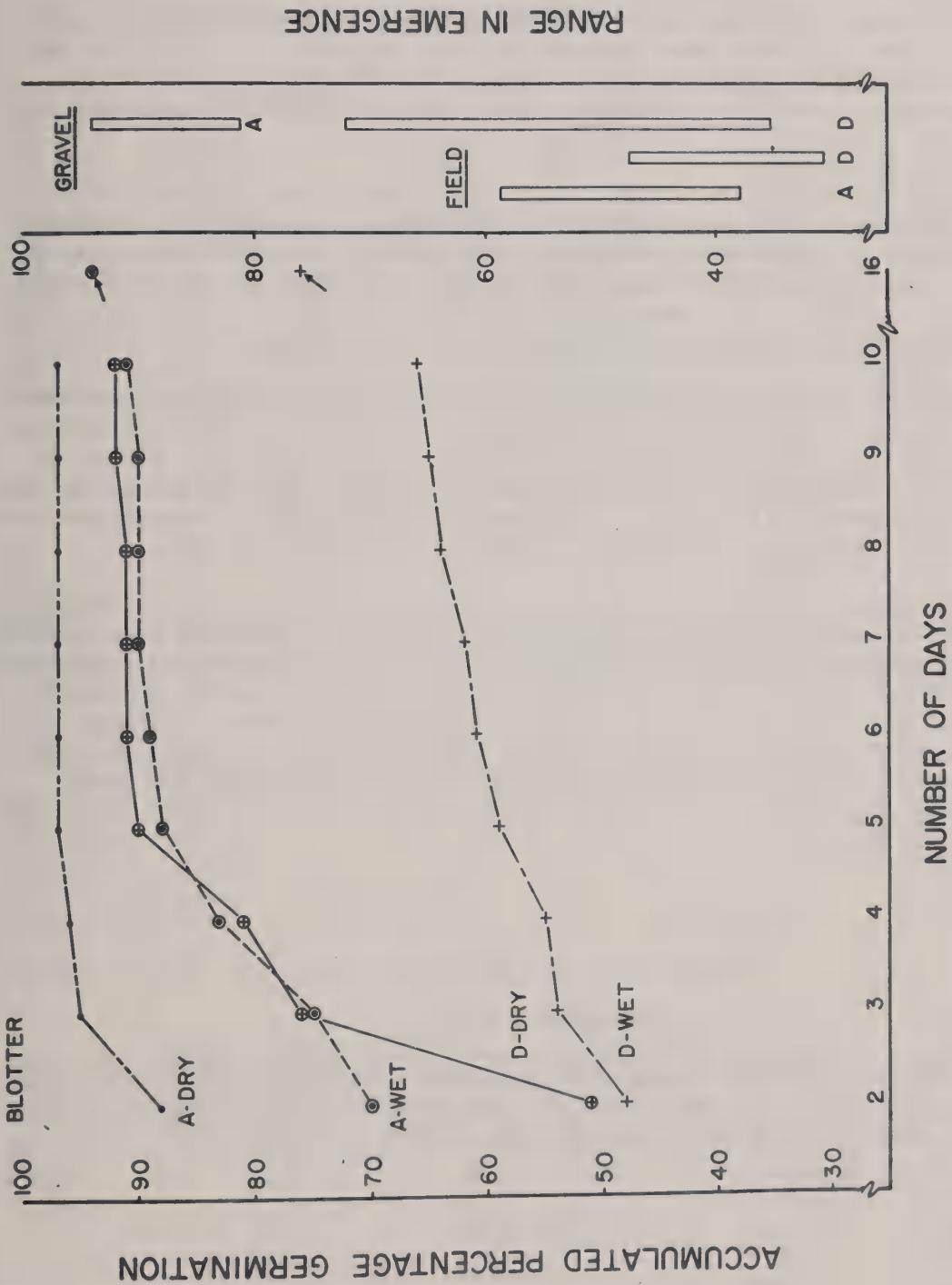


Figure 1. (Left side) blotter germination of seedlots A and D on moderately dry and on very wet blotters. Fruits removed from wet blotters on 10th day and placed on moderately dry blotters. Points on 16th day indicate increase in germination. (Right side) range in field and gravel emergence for seedlots A and D.

## RELATION OF FRUIT AND SEED SIZE TO SUBSEQUENT COTYLEDON AND LEAF AREA

F. W. Snyder and G. J. Hogaboam

Fruit and seed size in a monogerm cultivar have been related (1). However, they have not been related to cotyledon and leaf area at specific times after emergence. Cultivars with more rapid accretion of photosynthetic area could increase the yield of recoverable sucrose per acre.

After the diameters of the whole fruit and of the true seed (soft X-ray technique) were determined, each fruit was planted in vermiculite (16 oz thermal containers) and grown in a growth chamber. An excess of complete mineral nutrients was added daily. The size of the cotyledons within 16 to 24 hr after emergence, and of the fully expanded cotyledons and the leaf area 15 days after emergence were measured.

The four characters were not consistently related for all cultivars (Tables 1 and 2). No reason can be given for the divergence of data for two groups of plants grown from US H20 seed, since they were grown in consecutive experiments in the same growth chamber with no change in settings. The second set of data involved "seeds" that were soaked and re-dried before planting, whereas the first set was planted dry.

The relatively low association between these characters is logical since no selection pressure for association between them has been systematically applied in these cultivars. Fruit size and seed size both correlate rather poorly with leaf area 15 days after emergence. Therefore, selection for larger fruits or larger true seeds, without relating this to subsequent leaf area, may do little to improve a cultivar. The variations noted indicate that an integrated type of selection for these characters could lead to cultivars that accrete leaf area more rapidly in the seedling stage.

### Literature cited

1. Hogaboam, G. J. and Snyder, F. W. 1964. Influence of size of fruit and seed on germination of a monogerm sugar beet variety. J. Amer. Soc. Sugar Beet Technol. 13(2): 116-126.

Table 1. Relationships of fruit and seed sizes to subsequent cotyledon and leaf area of sugarbeet.

Cultivar	Seed source	Attrib.	Seed size	Cotyledon area at 16-24 hr	15 day	Leaf area 15 day	df
Whole fruit size							
US H20							
bulk							
US H20	bulk	"	0.27NS	0.55**	0.42*	0.11NS	33
A21-64	1 plant	"	0.58**	0.37*	0.53**	0.58**	29
A15-63	1 plant	"	0.52**	0.24NS	-0.07NS	0.06NS	23
C	1 plant	"	0.69**	0.59**	0.24NS	0.36NS	23
US H20	bulk	"	0.05NS	-0.34NS	-0.07NS	-0.16NS	10
Seed size							
US H20	bulk	"	-	-0.08NS	0.08NS	-0.16NS	32
US H20	bulk	"	-	0.49**	0.45*	0.46**	29
A21-64	1 plant	"	-	0.14NS	0.00NS	0.30NS	22
A15-63	1 plant	"	-	0.61**	0.69**	0.44*	23
C	1 plant	"	-	-.52NS	-0.16NS	0.51NS	8
16-24 hr cotyledon area							
US H20	bulk	"	-	-	0.46**	0.36*	32
US H20	bulk	"	-	-	0.47**	0.56**	30
A21-64	1 plant	"	-	-	0.18NS	-0.34NS	22
A15-63	1 plant	"	-	-	0.53**	0.48*	23
C	1 plant	"	-	-	0.63*	0.10NS	10
15 day cotyledon area							
US H20	bulk	"	-	-	-	0.43*	32
US H20	bulk	"	-	-	-	0.75**	30
A21-64	1 plant	"	-	-	-	0.21NS	22
C	1 plant	"	-	-	-	0.54NS	10

Table 2. The four size characters for the cultivars.

Cultivar	Whole fruit*		Seed*		Cotyledon area		Leaf area@	
	Mean	S. D.	Mean	S. D.	16-24 hr Mean#	S. D.	15 day Mean@	S. D.
US H20	11.5	±2.2	5.7	±0.5	25.6	±5.1	8.2	±1.4
US H20	12.4	±1.9	5.8	±0.5	28.5	±6.6	9.2	±1.8
A21-64	10.7	±1.0	6.3	±0.5	29.3	±6.1	8.7	±2.1
A15-63	8.6	±1.5	5.1	±0.6	18.2	±5.8	5.2	±1.1
C	9.9	±1.1	5.7	±0.5	27.1	±7.9	5.5	±0.6
A19-66	14.0	±0.9	6.6	±0.5	-	-	7.2	±1.5

\* In./64, # mm<sup>2</sup>, @ cm<sup>2</sup>.

BREEDING SUGARBEETS FOR RESISTANCE  
TO BLACK ROOT AND LEAF SPOT

G. E. Coe

Research work on sugarbeets at the Plant Industry Station, Beltsville, Md. is directed mainly toward varietal improvement in resistance to Aphanomyces black root and Cercospora leaf spot, important diseases in eastern United States.

Highlights of the work at Beltsville are set forth in this report.

Changes in Nursery Testing Techniques

In 1971, closer within-row spacing was used in the Beltsville nursery. Rows, however, were spaced 2 ft. apart as in previous years. A John Deere Model 33 vegetable planter with home-made attachments for the seed hopper was used in plot plantings in an attempt to space the seeds 4" apart in the row. The mechanical difficulties encountered in this first attempt were overcome sufficiently to obtain a satisfactory planting. Where seed germination approached 100%, there were almost no skips in the 4-inch spacing in spite of the fact that soil moisture conditions were not optimum for germination. Occasional skips in lines having good germination were probably due more to failure of seed plate cell-fill rather than to disease or insect damage.

A preemergence herbicide of 4 lbs. pyramin and 8 lbs. of T.C.A. was applied immediately after planting. A post-emergence herbicide of 2 lbs. of pyramin and 2 lbs. of Dowpon was applied when the beets were in the 4-leaf stage. The beets were singled soon after the application of the post-emergence herbicide, but no hills were removed. In monogermin varieties almost no singling was required, but multigerm lines required removal of excess plants in almost every hill. No hoeing of weeds was necessary. No hoeing was done all season in the first 48 rows of the nursery plot which were planted at a normal planting date. Later planted beets were hoed 1 time.

The results in 1971 were most gratifying. Weed control was the best yet seen at Beltsville. Root yields were also higher than they have ever been, but this was probably due more to the favorable growing season than to close spacing of beets. Plant losses, chiefly due to root rotting disease, between June 1 and harvest time were as high or higher than they have ever been, ranging from about 10% to 50%, except for a few lines which retained almost every hill in the row.

It will be several years before we can determine if selection among closely-spaced plants will be more effective than selection among more

distantly-spaced plants, and even longer to determine if it is possible to select for lines which will produce superior yields at close spacings. However, this is a line of research which can be conducted without interfering with the other objectives of the Beltsville research program, and in fact, reduces the expense of nursery testing.

#### Breeding for Black Root Resistance .

From 1954 to 1970, progress in improving sugarbeets in resistance to black root had been by small increments. However, tests in 1970 and 1971 revealed that a new variety, SP 6934-0, has resistance to black root which is considerably superior to any other variety or line tested thus far. SP 6934-0 is an elite multigerm line produced by interpollinating 5 clones from plants whose progenies had been outstanding in black root and leaf spot resistance. (Hybrids have been made with SP 6934-0 for testing in 1972.) It is encouraging that increases of this magnitude in black root resistance can be attained. Undoubtedly, this degree of resistance can be incorporated into commercial varieties in time, and further reduce field loss of young plants to this disease.

#### Progress in Improving Leaf Spot Resistance

Individual monogerm plant progenies produced at E. Lansing and tested in the Beltsville Nursery in 1971 exhibited a high degree of resistance to Cercospora leaf spot. Resistant multigerm check varieties were replaced by monogerm varieties in 1971 (because of the change in our planting method) making it difficult to compare 1971 leaf spot evaluations with evaluations of lines tested in previous years. However, the East Lansing monogerms appear to be another step forward in leaf spot resistance.

The leaf spot resistance of new Beltsville monogerm O-types was disappointing. Only 1 had resistance superior to O-types now being tested in hybrid combinations.

#### New Lines Producing Promising Experimental Hybrids

SP 69550-01 mm MS x SP 6322-0 has been a promising hybrid in field trials. However, considerable difficulty has been encountered in seed production of the male-sterile parent, yields being less than 50% of most other male-sterile lines. Preliminary tests indicate 3 new male-sterile lines, (SP 68533-01 mm MS, SP 67553-01 mm MS, and SP 68747-01 mm MS) produce hybrids which may be as desirable as SP 69550-01 x SP 6322-0. Although they may be slightly lower in sugar and purity, their increased tonnage may more than compensate for these decreases. Seed increases are being made of these new male-sterile lines.

A new multigerm pollinator line SP 66288-24 has produced hybrids with better leaf-spot resistance and apparently with better sugar percentage and purity than comparable hybrids using SP 6322-0 as pollinator. These hybrids need more field trials to establish whether or not SP 66288-24 is superior to SP 6322-0 as a pollinator.

Testing of Globe-shaped "Sugarbeets"

Preliminary observational plots of globe-shaped "sugar-beets" were unsatisfactory in 1971. The plots were planted in 6" rows and the seeds spaced 6" apart in the row. Moisture conditions at planting time were poor, and seedling emergence was unsatisfactory in most plots especially the commercial hybrid check plot which was the lowest yielding plot. Harvest results are presented in the following table.

<u>Variety</u>	<u>Roots</u> T/A	<u>Sucrose</u> %	Soluble	Leaf	<u>Plant</u> <u>Population</u> <u>Plants/Acre</u>
			<u>Non-Sucrose</u> <u>Solids</u> %	<u>Spot</u> <u>Rating</u>	
US H20	16.84	11.0	2.94	3	21,800
Globe Hybrid #1	19.28	7.1	2.51	6	30,500
" " 2	28.58	7.5	2.90	5	55,200
" " 3	23.16	7.1	2.89	4	50,800
" " 4	27.58	7.6	2.73	5	97,300
" " 5	22.86	8.1	2.82	5	81,300
MM Globe pollinator #1	25.98	8.9	2.53	6	85,700
" " "	19.66	8.5	2.70	6	69,700

Low sugar percentages are partially due to early harvest date. Sugar percentages and yields of globe-shaped lines were depressed by heavy leaf spot infestation. Additional crosses to leaf spot resistant sugarbeets will be needed before an accurate assessment of the potential of globe-shaped beets can be made. It is quite disappointing that 40-ton yields were not achieved on these small plots. Also, root shapes were not ideal, indicating the necessity of additional selection work.

PHYSIOLOGICAL AND HISTOLOGICAL STUDIES  
ON SUGARBEETS

R. M. Cressman

I. Growth and Accumulation of Sucrose in Sugarbeets

The purpose of this year's study was to survey a number of varieties and several types of beets with respect to several growth characteristics and sugar accumulation. The specific objectives for this year were (1) to compare low sucrose beets (fodder) and high sucrose beets with commercial beets, (2) to obtain general information on several growth measurements during the season, and (3) to measure the variability among beets of several varieties. Variability and general performance will be used as a basis for selecting a few varieties for subsequent work.

Varieties used included:

Commercial varieties: Am 3 Hyb A, Am 2 Hyb B, Am 3 Hyb N, Am 3 Hyb T, IS 93, IS 96, IS 951, HH 10, HH 19, Bush Mono, Zwaanpoly.

Fodder varieties: Ft. Collins lines 67-9094 (A58-5) and 65-9702 (Ovana).

Experimental high sucrose line: American Crystal Sugar Company line 67-436.

Seed was planted May 28, 1971. Starting July 6, nine adjacent beets from each variety (except, three of the high sucrose line) were dug every two weeks until the final harvest. Tops were removed at the base of the lowermost leaves for fresh and dry weight determinations, and fresh weight and percent sucrose were determined on the roots. Data were taken on the beets individually. During the early harvest, roots were visually examined for sucrose accumulation by a method involving precipitation of sucrose in the cells by means of  $Ba(OH)_2$ <sup>1/</sup>. After most of the harvests, permeability of the tissue to sucrose was also determined on one beet of 12 of the varieties by the procedure I described in Sugarbeet Research, 1968 Report.

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<sup>1/</sup>Cressman, R. M. The use of  $Ba(OH)_2$  in methanol for demonstration of the distribution of sucrose in sugarbeet roots. *Stain Technol.* (In press).

The data, averaged according to beet type, are given in Table 1. Root yield increased rapidly during August but leveled off in September. Top fresh weight increased rapidly during July, reached a peak in late August, and declined during September. Sucrose concentration increased steadily from early July until harvest although the rate of increase lessened slightly during September. Gross sucrose increased almost linearly from late July to mid-September.

Compared with the commercial beets, the fodder beets (which characteristically produce larger roots and lower sucrose) accumulated sucrose more slowly, maintained a lower top to root ratio and had slower development of the leaves. The high sucrose beets, compared to the commercial beets, had smaller roots, maintained a higher top to root ratio during August and September, and developed a higher rate of sucrose accumulation during September. No great differences in variability occurred among the commercial varieties tested. The average coefficients of variation for all harvests of each variety ranged from 31 to 43% for root weight, from 28 to 39% for top fresh weight, and from 7 to 12% for the sucrose concentration.

In young beets, sucrose gradually accumulated in all the storage tissue. The low amounts of sucrose in the cells of the interzonal parenchyma were clearly distinct from the mass accumulation in mature beets as illustrated in Figures 1 and 2.

Permeability of beet sections to sucrose is listed in Table 1 as sucrose loss in distilled water after 6 hours. Although the "high sucrose" beets usually showed higher diffusion rates, some of the commercial beets often had rates which were as high or higher, but the relative magnitude of the rates was not consistent within a variety. During the early growth period, whether the permeability of the tissue to sucrose can be correlated with a high potential for sucrose accumulation cannot be determined from the present data but would need to be evaluated by the selection and breeding of individual beets.

## II. Storage Versus Permeability of Beet Tissue to Sucrose.

In April, 1971, three varieties of beets which had been stored in moist wood shavings in a cold room (about 5°C) were moved to a warm room where the temperature was above 15°C.

Table 1. Growth of sugarbeets planted May 28, 1971.

	Weeks after planting							
	5.5	7.5	9.5	11.5	13.5	15.5	17.5	19.5
<b>Yield (T/A)</b>								
Commercial	---	2.7	5.7	10.6	15.4	21.5	20.7	21.3
Fodder	---	3.7	8.9	16.3	25.0	32.7	29.9	28.1
High sucrose	---	0.8	2.4	5.1	6.2	8.5	10.2	---
<b>Top fresh wt (g/plant)</b>								
Commercial	75	483	809	982	950	1075	761	767
Fodder	61	456	600	755	685	884	586	512
High sucrose	30	291	406	681	897	579	724	---
<b>Sucrose (%)</b>								
Commercial	5.2	5.8	8.9	11.8	13.5	12.5	16.3	16.9
Fodder	4.4	5.1	5.4	6.9	8.3	6.4	9.3	9.2
High sucrose	5.3	7.6	11.0	13.5	14.9	15.6	20.1	22.1
<b>Gross sucrose (T/A)</b>								
Commercial	---	0.16	0.51	1.23	2.07	2.66	3.37	3.57
Fodder	---	0.19	0.48	1.12	2.08	2.03	2.71	2.58
High sucrose	---	0.06	0.27	0.68	0.92	1.33	2.04	---
<b>Top/root ratio</b>								
Commercial	10.7	4.48	3.52	2.28	1.50	1.22	0.89	0.87
Fodder	8.1	2.89	1.74	0.98	0.69	0.43	0.44	0.33
High sucrose	12.2	6.06	3.44	2.38	2.13	1.40	1.53	1.26
<b>Permeability (mg sucrose/g beet lost after 6 hr)</b>								
Commercial	3.3	---	10.2	22.4	26.5	18.1	24.4	29.8
Fodder beets	2.6	---	4.8	15.8	16.1	7.2	13.9	24.9
High sucrose	8.6	---	27.2	12.9	27.7	19.5	57.0	41.5



Fig. 1. Sugar accumulation in young beet. X16.



Fig. 2. Sugar accumulation in mature beet. X12.

Beets were removed at intervals and the permeability determined on discs of tissue. The results are given in Table 2. Despite some visual deterioration in the beets towards the end of the period, no obvious changes in the permeability were evident.

Table 2. Permeability to sucrose of discs from beets stored above 15°C.

Variety	Mg Sucrose/g beet lost after 6 hr							
	Weeks at room temperature							
	1	2	4	6	8	10	13	17
Am 3 Hyb N	7.4	8.1	6.7	6.8	5.7	6.0	6.9	10.6
IS 951	4.4	8.2	4.9	6.1	4.6	5.1	4.5	7.1
Ovana	3.6	3.5	4.7	3.9	3.3	3.1	1.6	5.4

In a second experiment, beets harvested in October of 1971 were stored in perforated plastic bags in a cold room at 5°C and high humidity. Two beets each of varieties Am 2 Hyb B, Am 3 Hyb N, Bush Mono, IS 93, Ovana (Fodder), and American Crystal line 67-436 (high sucrose) were used. Cores were removed at monthly intervals with a cork borer and permeability determined on discs of the beet tissues. Results are given in Table 3. No definite trends are apparent at this time. The values are much higher than those obtained in previous years.

Table 3. Permeability of discs from beet roots during storage at 5°C.

Beet	Mg Sucrose/g beet lost in 6 hr			Sucrose %*	
	Weeks of storage				
	4	8	12		
Am 2 Hyb B	29.6	27.0	43.8	20.2	
Am 2 Hyb B	69.7	58.0	74.7	20.0	
Am 3 Hyb N	38.8	48.7	42.9	17.0	
Am 3 Hyb N	21.8	23.2	25.7	16.1	
Bush Mono	17.0	17.4	25.0	11.9	
Bush Mono	28.7	23.6	47.9	14.9	
IS 93	48.2	57.8	59.4	19.2	
IS 93	42.1	33.1	42.8	17.7	
Ovana	9.4	17.5	21.9	7.2	
Ovana	16.9	19.6	10.4	9.7	
High sucrose	73.2	55.0	57.2	22.0	
High sucrose	49.8	37.8	48.2	19.1	

\* Average of the 3 sections.

### III. Distribution of Sucrose in the Sugarbeet

Studies have been in progress to determine the distribution of sucrose within the beet in order to assess the efficiency of sucrose accumulation in various parts of the beet and to help to estimate the potential for accumulation. A radial segment several millimeters wide and thick was cut from a beet. The segment was divided into the central core (C), the individual vascular rings, and the bands of interzonal parenchyma (interzones). In some large beets with broad interzones, the interzones were subdivided. The sections of tissue were weighed, the sugar extracted by boiling, and,

after appropriate dilutions, the sugar concentrations were determined by the phenol-sulfuric acid procedure<sup>2/</sup>. Segments were taken from upper and lower portions of the beets and from opposite sides.

Typical data are illustrated in Tables 4 and 5. In Table 4, "A" is a high sucrose beet and "B" is Am 3 Hyb N. Sucrose concentrations are lower in the interzonal parenchyma than in the tissues of the vascular ring, particularly in the interior regions of the beet. Generally, the lower the average sucrose concentration in the beet, the greater the difference between ring and interzone. Segments from opposite sides of the beet showed similar patterns and only small differences in the actual sucrose concentrations in analogous tissues. In segments from the lower portion of the beets, the differences between the ring and interzone tissues were less and the sucrose concentrations of the rings were slightly lower than in the segments from the upper portion.

Table 5 illustrates the sucrose distribution in a fodder beet, which has few widely spaced vascular rings. Table 6 shows the sucrose distribution found in a large beet of a commercial variety. In both cases, the sucrose concentrations in the middle of the interzones were very low. This highly unequal distribution indicates that there is preferential storage of sucrose in the storage tissues of the vascular rings when much of the sucrose is being used in growth rather than being stored.

Much of the variation in sucrose percentage often noticed in sampling individual beets probably results from the proportion of various tissues included in the sample. In the beets studied, sucrose concentrations were rather uniform among the tissues of the vascular rings as compared to the tissues of the interzones. From a selection viewpoint, beets with a lower proportion of interzonal parenchymatous tissue to vascular ring tissue may be more efficient in accumulating sucrose when cultural conditions are less than optimum.

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<sup>2/</sup> Dubois, Michel, K. A. Gilles, J. K. Hamilton, P. A. Rebers, and Fred Smith. 1956. Colorimetric method for determination of sugars and related substances. *Anal. Chem.* 28: 350-356.

Table 4. Sucrose concentrations in vascular rings and inter-zones of sugarbeets.

Ring No.	Percent Sucrose			
	Beet A (22.9% sucrose)		Beet B (19.6% sucrose)	
	Interzone	Ring	Interzone	Ring
C		23.7		21.2
1	20.2	23.4	13.7	20.9
2	20.9	23.3	16.5	21.5
3	22.2	24.3	15.9	22.1
4	21.9	24.2	17.7	22.1
5	23.2	24.4	19.0	22.0
6	24.3	24.2	21.9	22.2
7		24.1		22.4
8+		23.6		21.3

Table 5. Sucrose concentrations in vascular rings and inter-zones of fodder beet (7% sucrose).

Ring No.	Percent Sucrose		
	Interzone	Ring	
C			9.5
1	7.9	3.9	4.5
2	7.4	5.1	3.8
3		7.1	5.6
		4.4	5.0
			9.4

Table 6. Sucrose concentrations in vascular rings and inter-zones of a large sugarbeet (American 3 Hybrid N; 6.4 lbs; 11.1% sucrose).

Ring No.	Percent Sucrose		
	Interzone	Ring	
C			12.9
1	9.8	3.0	6.9
2	10.5	5.0	9.9
3	12.1	5.7	7.7
4	12.1	6.3	9.2
5	13.5	9.0	9.0
6		10.0	9.8
7			11.5
			14.1

Storage Decay Studies<sup>1/</sup>  
W. M. Bugbee

Pectolytic enzyme production  
by Phoma betae

Phoma betae is an important pathogen of stockpiled sugar-beets in the North Central Region. Little is known about the physiology of this fungus, especially the production of macerating enzymes which are important in the degradation of plant tissue. In preliminary experiments I could not obtain the amount of pectolytic enzyme activity from culture that would be expected based on the ability of this fungus to cause decay. Therefore, experiments were designed to learn the cultural requirements for pectolytic enzyme production and to determine if these enzymes were present in infected tissue.

Materials and Methods

All culture work was done as liquid-still cultures in 125 ml Erlenmeyer flasks containing 20 ml of medium. The inoculum was an agar plug 3 mm in diameter taken from the edge of a colony. This isolate was obtained from decayed storage root tissue. Sugarbeet storage roots were inoculated by surface disinfesting an area of the storage root with 95% ethanol then inoculating with a toothpick culture. The toothpicks had been boiled, soaked in potato-dextrose broth, then autoclaved.

Effect of Nitrogen source. The base medium contained 1% pectin (w/v), 0.3 gm MgSO<sub>4</sub>, 1.5 mgm Fe(NO<sub>3</sub>)<sub>3</sub>, 0.9 mgm ZnSO<sub>4</sub> and 0.4 mgm MnSO<sub>4</sub> in 1,000 ml distilled water. The following nitrogen sources and their amounts were calculated to give about the same amount of nitrogen for each series per liter of base medium: ammonium tartrate 3.30 gm, glycine 2.64 gm, asparagine 3.10 gm, KNO<sub>3</sub> 2.64 gm, NH<sub>4</sub>NO<sub>3</sub> 1.42 gm, and (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> 2.4 gm. The pH was adjusted to 6.1 before autoclaving. The cultures were incubated at 22C.

Enzyme assays. Cultures were filtered through No. 3 qualitative filter paper. The filtrate was centrifuged for 15 minutes at 3,500 g then dialyzed in 100-175 volumes of glass distilled water at 4C for 17-22 hr. Mycelia were dried at 65C for 24-48 hr. Mycelial weights are averages of four cultures. Infected or healthy sugarbeet tissue was homogenized for 2 minutes in 0.5N NaCl then filtered, centrifuged, and dialyzed as above.

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1/ In cooperation with the Agricultural Experiment Station,  
North Dakota State University, Fargo.

Pectin methyl esterase (PME) activity was determined as described in the 1970 Sugarbeet Research Report.

PG and trans-eliminase activity was determined using viscometry and semi-micro thiobarbituric acid (TBA) test. Viscosimetric determinations were made in No. 300 Fenske-Ostwald viscometers at 30C. The reaction mixture for viscometry contained: 5ml of 1% sodium polypectate (NaPP) in 0.1M acetate buffer at pH 4.5 or 1% pectin in .05M tris buffer at pH 8.5 and 1 ml of dialyzed enzyme. Viscosimetric units (VU) are defined as the reciprocal X 100 of the time in minutes to reduce the viscosity by one-half. The reactions were not run longer than 1 hr. The reaction mixture for the TBA test contained 5 ml of NaPP or pectin as described above; 1 ml of distilled water in the NaPP series or 1 ml of 0.01M  $\text{CaCl}_2$  in the pectin series; and 4 ml of dialyzed culture filtrate or root extract. The mixture was incubated for 2 hr at 30C. After incubation, the mixture was poured into 35 ml centrifuge tubes and 0.6 ml of 9%  $\text{ZnSO}_4$  and 0.6 ml of 0.5N NaOH was added to precipitate protein and excess substrate. The mixture was centrifuged at 3,500 g for 15 minutes. To 5 ml of the cleared product was added 3 ml of 0.04M TBA, 1.5 ml of 1N HCL and 0.5 ml of distilled water. This was boiled in a bath for 30 minutes to develop the color. Absorbance was measured on a double beam spectrophotometer. Enzyme activity was expressed as 100 times the increase in absorbance per hr per ml of enzyme. Measurements of PG activity were made at 510 nm and for trans-eliminase activity at 550 nm.

The release of D-galacturonic acid was measured using the dinitrosalicylic acid (DNS) method. The reaction mixture contained 4 ml of 0.3% NaPP in acetate buffer at pH 4.5 or 0.3% pectin in Tris buffer at pH 8.5 plus 1 ml of dialyzed culture filtrate or root extract. This was incubated at 30C for 1 hr.

In all enzyme assays, enzyme preparations that had been placed in a boil-bath for 30 minutes were used as controls.

Isolated cell wall material was prepared from fresh storage root. Root tissue was diced to 2 mm then homogenized 2 minutes in cold 100 nm phosphate buffer at pH 7.0. This was centrifuged at 3,500 x g and washed three times by centrifugation in 35 ml of buffer then filtered and washed three times with 25 ml of cold acetone. The material was air dried then ground in a Wiley mill to pass a 60 mesh screen.

Sugarbeet varieties used were A58, a fodder beet, low in sucrose and susceptible to P. betae; and American 2 hybrid B (2B), a variety grown extensively in the Red River Valley and more resistant to P. betae than A58.

## Results and Discussion

Effect of nitrogen source. Of the six sources of nitrogen tested,  $(\text{NH}_4)_2\text{SO}_4$  resulted in the greatest amount of PG production. A VU of 1.8 was obtained after 4 days incubation. This increased to 8.3 after 16 days compared to 7.5 for glycine.  $(\text{NH}_4)_2\text{SO}_4$  at 2.4 gms/L was used as the nitrogen source in the remaining experiments.

Effect of temperature. A preliminary test showed that the greatest mycelial weight after 12 days incubation was at 15-20C. The temperature range in this test was 5-30C at 5C intervals. In a second test, only temperatures of 15, 20, and 25C were used but measurements were made at 8, 12, 16, and 20 days to determine more precisely the rate of enzyme production. In this test, maximum growth was reached at 16 days at 15C but the maximum specific activity of PGTE, as measured by the TBA test at 550 nm, occurred at 12 days and 20C.

Viscosimetric measurements made at 12 days for incubation temperatures of 5, 10, 15, 20, and 25C gave VU values of 0, 13, 33, 111 and 40 respectively when pectin was the substrate at pH 8.5. A 50% reduction in viscosity of NaPP at pH 4.5 never occurred.

According to the DNS test, dialyzed culture filtrate from the 20C incubation temperature had 185 units of enzyme activity when NaPP was the substrate but none when pectin was the substrate.

The rapid release of reducing groups but slow reduction in viscosity and low production of galacturonic acid residues when NaPP was the substrate at pH 4.5 indicates the production of exo-PG. The slow release of reducing groups, rapid loss in viscosity, and high absorption at 550 nm when pectin was the substrate at pH 8.5 indicates the production of endopolygalacturonate trans-eliminase (endo-PGTE).

Enzymes from infected storage roots. Whole sugarbeet storage roots were incubated at 10C for six weeks after being inoculated with *P. betae*. Dialyzed extracts from infected or healthy sugarbeet tissues were tested twice for PME activity. None was present.

Viscosity tests using pectin or NaPP at pH 4.5 or 8.5 showed that enzymes present in extracts of infected tissues reduced the viscosity of pectin at pH 8.5 or NaPP at pH 4.5. Therefore, further viscosity, TBA, and DNS tests were conducted using pectin at the high pH and NaPP at the low pH.

The TBA test for unsaturated products when pectin was the substrate showed activity in extracts from rotted tissue. Activity also was present in extracts from adjacent and healthy tissue but at a lower level. There was no activity with NaPP as the substrate.

The DNS test showed that a greater amount of D-galacturonic acid was released from pectin than from NaPP. Much lesser amounts were present in extracts from adjacent or healthy tissue. The addition of 1 ml of .01 M  $\text{CaCl}_2$  to the reaction mixture stimulated the activity of endo-PGTE. Without  $\text{Ca}^{++}$ , the enzyme units as measured by the DNS test were 60 but with the addition of  $\text{Ca}^{++}$ , 870. The addition of 1 ml of  $1 \times 10^{-4}$ ,  $10^{-6}$ , or  $10^{-8}$  M  $\text{CaCl}_2$  did not stimulate endo-PGTE activity.

When a dialyzed extract of rotted tissue was allowed to react with pectin or NaPP, the viscosity of pectin decreased more rapidly than NaPP. The relative viscosity units with dialyzed extracts was 91 and 49 when pectin and NaPP were the respective substrates, but the VU values were 500 and 102 respectively when undialyzed filtrates were used. Also, there were 55 units of relative activity in undialyzed extracts from tissue adjacent to the rotted area with pectin as the substrate. Dialysis greatly reduced this activity. There was no evidence of depolymerization ability in extracts from healthy tissue.

Cell walls as the carbon source. *P. betae* was grown in a liquid medium with cell walls of sugarbeet storage roots as the carbon source. Thiamine,  $(\text{NH}_4)_2\text{SO}_4$ , with incubation at 20C for 12 days was used because these factors were found optimum for exo-PG and endo-PGTE production when pectin and NaPP were the carbon sources. Absorption of products of depolymerization in the TBA test showed greater enzyme activity on pectin at pH 8.5 than on NaPP at pH 4.5. In the DNS test there was a rapid release of D-galacturonic acid when NaPP was the substrate but none when pectin was the substrate. This indicates, as did the data from the temperature experiments, the production of exo-PG and endo-PGTE.

The source of cell wall material influenced enzyme production. Specific enzyme units of exo-PG and endo-PGTE, as determined by the TBA test, were greater in filtrates from the A58 cell wall cultures than from the 2B cell wall cultures. But in the DNS test, more units of exo-PG were present in the 2B cell wall culture than in the A58 culture.

Healthy sugarbeet storage roots used in these experiments and those produced on the alkaline soils of the Red River Valley have a pH in the range of 6.2-6.7. The pH of tissue infected with *P. betae* did not drop below this range during early rot development but gradually increased to pH 7.0 in these tests. Additional measurements of rotted sugarbeet roots have shown pH values of 8.0. Tissue within 3 mm of rotted tissue was pH 6.4 and the undialyzed extract contained active endo-PGTE but no measurable amount of exo-PG in the dialyzed or undialyzed extract. The relatively high pH of these tissues and the absence of exo-PG from advancing margins of rotted tissue suggests that endo-PGTE plays a major role in this particular relationship.

When I used sugarbeet cell wall material as the carbon source, the susceptible A58 medium induced more endo-PGTE than the more resistant 2B medium. This relates to the general consensus in the sugarbeet industry that roots low in sucrose do not store as well as those high in sucrose. The association of high endo-PGTE production in culture with cell wall material from a susceptible host as the only carbon source suggests that characteristics of the cell walls plays a part in regulating pectolytic enzyme production. Further investigations in this area may lead toward reducing storage losses especially when sugarbeets with low sucrose must be stockpiled.

#### Factors affecting Phoma storage rot of sugarbeet.

There is a general consensus that sugarbeets low in sucrose do not store as well as those with a higher or normal sucrose of mature beets. This observation was investigated using *Phoma betae* as the storage rot pathogen and one variety of fodder beet and two commercial varieties of sugarbeets.

Roots with various stages of maturity were obtained by harvesting at 2-week intervals from August 16 to September 27, 1971. A final harvest was made on October 27. Six storage roots were inoculated with *P. betae* after each harvest. The toothpick method was used. Sucrose content was measured from a seventh beet. The results in Table 1 show that as American 2 hybrid B (2B) and American 3 hybrid N (3N) matured, they became more resistant to *P. betae*. The disease ratings for A 58, a fodder beet, were not as consistent as the sugar types, but revealed the susceptible nature of this variety. The month of October was overcast and rainy and probably accounted for the reduction in percentage sucrose during that time. The resistance in the sugar types increased greatly during October even though sucrose percentage decreased.

This sucrose-resistance relationship was examined more closely by selecting the most susceptible and most resistant sugarbeet from variety 2B and A58. The sucrose content was measured for each root and crown. The susceptible root of 2B at each harvest date had a sucrose content lower than the more resistant root, although this difference only amounted to 0.3% at the final harvest. A similar relationship existed in the variety A58, except at the September 27th harvest where the most susceptible crown and root tissue had the higher sucrose content.

Factors other than sucrose may be involved here because even though the sucrose increased with age from 10 to 16.7% in susceptible roots of variety 2B, the disease ratings remained very close. In other words, the increase in sucrose, as the roots matured, was not always associated with a proportionate decrease in susceptibility to P. betae. The data in Table 2 also indicate that the crown area is not always more susceptible than the root.

Other researchers, using other host-pathogen combinations, have shown that isolated cell wall material from susceptible hosts induce more cell-wall degrading enzyme production than wall material from resistant plant tissue. The next experiment was designed to see if pectolytic enzymes from cultures of P. betae would induce strength loss in thin slices of storage root tissue and if differences could be associated with varietal response. Tissue slices, .250 mm thick and 14 mm in diameter were prepared from the same crown and root material used in the previous test. These slices were placed in cell wall degrading enzymes of P. betae for 1.5 hours, then tested for strength. The loss in strength was expressed as a percentage of the controls which were slices placed in water or boiled enzyme. Slices from resistant roots of 2B or 3N harvested on August 30 or September 27 also were more resistant to maceration than slices taken from susceptible roots. The reverse was true for A58, although the differences between susceptible and resistant tissue was small. There was no consistent association between resistance of whole roots to P. betae and resistance of slices to enzymes at the final harvest date. When considering the resistant roots of 2B and A58, those harvested on September 27 were more resistant to P. betae than those harvested on October 27. This was also true for slices taken from these roots and exposed to pectolytic enzymes of P. betae. The reaction of crown slices to enzymes was independent of the reactions of slices from roots. Since root slices occasionally responded predictively to cell free enzymes of P. betae based on whole root response, it is doubtful that sucrose content functions in a major way to regulate pathogenesis of P. betae.

To test this theory, isolated cell wall material from storage roots was used as the sole carbon source in a liquid medium for P. betae. Fungal growth (Table 4) and enzyme activity (Table 5) were measured in each culture. The data in Table 4 show that Phoma grew more rapidly on cell walls from older roots up through the September 27th harvest. Then the growth decreased on cell walls from the last harvest. There was more growth on cell walls from crown tissue but no correlation with susceptibility. There was a correlation among the disease reactions of roots from each harvest date (Table 1) with the amount of growth of Phoma on the cell walls (Table 5). The cell walls from the most susceptible variety supported the most growth of Phoma within each harvest date. Furthermore, during October, roots of 2B and 3N increased considerably in their resistance to Phoma. This was accompanied by a reduced ability of Phoma to utilize the cell walls as a carbon source. During the same time, A58 became more susceptible to Phoma and cell walls from A58 supported increased fungal growth.

Endo-polygalacturonate trans-eliminase (endo-PGTE) is an important cell wall degrading enzyme produced by P. betae. Measurements on the specific activity of this enzyme in culture filtrates of Phoma when grown on cell walls from different varieties show a general reduction in activity as the roots increased in age up to September 13 or 27th. Then the activity began to increase with cell wall age. During October, when growth of Phoma on cell walls was reduced, the production of endo-PGTE increased. Again, the production of endo-PGTE was correlated with varietal resistance within each harvest date. Interestingly, cell walls from 2B and 3N in their most resistant state from the final harvest induced more endo-PGTE production than younger beets with less resistance. Other factors must be inactivating this enzyme if it is being produced in proportionate amounts in intact roots.

There was no indication that enzyme production was consistently favored by either crown or root cell wall material.

Conclusions: As roots mature they become more resistant to Phoma storage rot but there is no clear correlation between resistance and sucrose content. Isolated cell walls from older roots support more fungal growth than walls from younger roots. The amount of endo-PGTE produced in the cell wall medium did not always correlate with the amount of fungal growth. But within each harvest date, the varietal response of storage roots to Phoma agreed with the amount of fungal

growth and endo-PGTE production on isolated cell walls. Under certain circumstances, root slices from different varieties lost strength differentially after exposure to enzymes. This agreed with the response of whole roots to infection. The data from these experiments suggest that the constituents of cell walls of storage roots play a part in regulating endo-PGTE production and the pathogenesis of P. betae.

Table 1. Disease rating (DR) and per cent sucrose of three varieties of sugar-beets harvested and inoculated with Phoma betae at different dates.

Harvest date	Variety					
	A58		2B		3N	
	DR	%S	DR	%S	DR	%S
8-16	188	7.1	131	11.4	---	---
8-30	102	7.7	96	11.9	112	1.30
9-13	186	5.2	140	11.6	155	13.5
9-27	112	9.4	110	17.1	88	17.5
10-27	184	6.5	68	15.3	61	14.8

a/ DR=sum of the longest and shortest distance in mm of lesion at the root surface multiplied by five.

Table 2. Disease rating (DR) and per cent sucrose of resistant and susceptible sugarbeets based on root reaction. Both crown and root were inoculated with Phoma betae.

Harvest date	Inoculation site	Variety					
		2B		A58		Susceptible	
DR	%S	DR	%S	DR	%S	DR	%S
8-30	crown	125	11.7	125	10.3	130	6.6
	root	70	12.0	145	10.0	85	7.0
9-27	crown	85	14.2	40	15.0	215	9.1
	root	85	16.8	140	15.5	100	6.8
10-27	crown	30	15.5	85	14.3	110	10.8
	root	40	17.0	140	16.7	90	10.5

Table 3. Strength of tissue slices after exposure to culture filtrate of Phoma betae. Disease reaction based on whole root response to inoculation with P. betae.

Harvest date	Source of slices	Variety					
		2B		3N		A58	
		%	%	%	%	%	%
8-30	crown	82	55	64	49	37	42
	root	88	70	76	66	39	35
9-27	crown	47	19	39	15	20	32
	root	39	15	36	23	31	40
10-27	crown	62	67	24	54	63	62
	root	70	101	42	45	74	112

Table 4. Growth of Phoma betae in a medium with isolated cell wall material from crown or root as the carbon source. Growth based on  $\mu$ g protein in mycelium per culture. Each figure is a average of three cultures.

Harvest date	Variety and source of cell walls					
	2B		3N		A58	
	root	crown	root	crown	root	crown
	$\mu$ g	$\mu$ g	$\mu$ g	$\mu$ g	$\mu$ g	$\mu$ g
8-16	840	982	--	--	912	898
8-30	994	1498	1555	1512	1325	1469
9-13	1584	1512	1556	1498	1915	1598
9-27	1857	2246	1930	3614	1728	2534
10-27	1786	2218	1656	2736	2045	2506

Table 5. Specific units of endopolygalacturonate trans-eliminase per mg protein in dialyzed filtrate from cultures with cell wall material from root or crown of different varieties.

Harvest date	Varieties and source of cell walls							
	2B		3N		A58		root	crown
	root	crown	root	crown	root	crown		
units								
8-16	448	407	---	---	538	535		
8-30	297	294	417	230	407	224		
9-13	214	162	307	370	372	247		
9-27	270	281	219	226	256	232		
10-27	315	326	328	396	414	366		

Evaluation of the World Collection of  
Beta sp. for resistance to P. betae

One way of alleviating storage losses is to use resistant varieties. Research by others has shown that breeding for resistance to Phoma betae is possible. A preliminary screening for sources of resistance was made in the world collection of Beta sp. Seed from 298 collections were planted at the Fargo Experiment Station. Lines that bolted were eliminated leaving 181 collections that were harvested. From these lines, 1,099 roots were inoculated with P. betae, incubated at 10C for 5 weeks then examined. There were 197 roots that appeared resistant and saved as mother beets. Of these, 56 were sugar types, 94 were mangels, and 47 were table types. Attempts will be made to obtain seed from the sugar types so that progeny can be evaluated further for resistance to P. betae.

Similar testing is in progress with all commercial varieties being grown in the Red River Valley plus new varieties that are being introduced.



